ROAD and STREET

Catalog and Data Book

1928

ROAD AND STREET CATALOG AND DATA BOOK

A Consolidation of Manufacturers' Catalogs of Highway, Road and Street Materials, Construction Plant and Maintenance Equipment

1928

Together With a Data Section of Engineering Information and Economic Methods on the Design, Construction and Maintenance of Highways, Roads and Streets, Compiled by Halbert P. Gillette, Editor of Roads and Streets, Author of Handbook of Cost Data and Handbook of Construction Costs.

Also Geographical Index of Dealers and Distributors

Fourth Annual Edition

Compiled, Edited and Published Annually by

Gillette Publishing Co.

Technical Publishers

221 East 20th Street, Chicago, Illinois

Halbert P. Gillette, **President** — E. S. Gillette, **Vice-President and Secretary** — E. B. Howe, **Vice-President**

FOREWORD

GILLETTE PUBLISHING COMPANY presents herewith the fourth (1928) edition of the Road and Street Catalog and Data Book.

The Data Section has been revised and enlarged by Mr. Halbert P. Gillette and gives the equivalent of a 500-page handbook of road and street data. The various specifications also have been brought up to date and data on a number of new subjects have been added.

The Data Section together with the Geographical Index of dealers and distributors together with the manufacturers' Catalog Data make this edition a very complete and practical reference book.

The demand for copies of this book has been so great that the 1928 edition will be distributed to 20,000.

The Data Section is carefully selected matter made from the files of Roads and Streets and from other sources named in the text. In additon, scores of letters have been written to secure the latest standards and specifications and the most economical construction methods. In a word, the same conscientious work has been put into the writing of the Road and Street Data Section as would be expected in a book devoted exclusively to this purpose.

LIST OF DATA SECTIONS

ROAD AND STREET DATA INDEX

ALPHABETICAL INDEX OF FIRM NAMES

ALPHABETICAL INDEX OF TRADE NAMES

CLASSIFIED INDEX OF PRODUCTS

All products are indexed under the main word. Specific headings refer to firms whose products are catalogued. See also trade name index, distributors' index and data section index, following classified index of products

G

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S

TO the User of this ROAD and STREET CATALOG and DATA BOOK

The cards provided below are for your use in requesting additional information from manufacturers represented in this book. Realizing that you may be using this book on the job, where writing materials are not handy, we hope these cards will serve a useful purpose.

If you do not find the products you need in the Catalog Section of this book, address one of these cards to us and we shall be glad to put you in touch with reliable manufacturers.

GILLETTE PUBLISHING COMPANY
Publishers of the
ROAD AND STREET CATALOG AND DATA BOOK

Use Geographical Index for Addresses of Local Distributors—Quick Service!

ROAD AND STREET CATALOG and DATA BOOK, Vol. IV

Request for Information

Gentlemen:
Please send additional information, prices, and terms on the following products:

....
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....

Name ....
Address ....
City .... State ....
Concern ....

ROAD AND STREET CATALOG and DATA BOOK, Vol. IV

Request for Information

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ROAD AND STREET CATALOG and DATA BOOK, Vol. IV

Request for Information

Gentlemen:
Please send additional information, prices, and terms on the following products:

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Name ....
Address ....
City .... State ....
Concern ....

Mailing Card

Place
Two-Cent
Stamp
Here

Mailing Card

Place
Two-Cent
Stamp
Here

Mailing Card

Place
Two-Cent
Stamp
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Mailing Card

Place
Two-Cent
Stamp
Here

GEOGRAPHICAL INDEX OF DEALERS AND DISTRIBUTORS

Note: Each equipment distributor's name is followed by the name of the firms whose products he handles. The alphabetical index of firms will be found on page 5.

See also lists on individual pages

Alabama

Birmingham

Alabama Equipment Co.
523-525 No. 28th St.
Heltzel Steel Form & Iron Co.

The Barrett Company
Age Herald Bldg. (Fairfield)

Blaw-Knox Company
Brown Marx Bldg.

Robert A. Boothe
3816 Ave. "A" South
Keystone Driller Company
Ryan Manufacturing Corporation

Bucyrus-Erie Company
2212 Comer Bldg.

Concrete Steel Company
Brown Marx Bldg.
Hoosier Asphalt Co.

A. A. Culp
235 Brown Marx Bldg.
Sullivan Machinery Co.

C. B. Davis Engineering Co.
410-412 Brown-Marx Bldg.
G. H. Williams Company

Drennen Motor Car Co.
Hydraulic Hoist Mfg. Co.

Edwards Motor Company
1620 Third Ave.
Ditwiler Manufacturing Co.

Engineers Supply Co.
2111 First Ave.
Buff & Buff Mfg. Co.

The Galion Iron Works & Mfg. Co.
3902 Avenue A S.

Going Road Machinery Co., Inc.
1624 First Ave., No.
Cleveland Tractor Co.

Harnischfeger Corporation
401 Pioneer Bldg.

Ingalls Iron Works
720 Avenue D.
Page Steel & Wire Co.

Ingersoll-Rand, Inc.
1700 Third Ave., South

International Harvester Co. of America

Moore & Handley Hardware Co.
Sullivan Machinery Co.
Western Wheeled Scraper Co.

G. C. Phillips Tractor Co.
1625 Ave. B, South
George Haiss Mfg. Co., Inc.

The Pittsburgh Plate Glass Co.

Seiler & Lavigne
412½ N. 21st St.
Williams Patent Crusher & Pulverizer Co.

Smith-Pittman Tractor Co.
521 N. 28th St.
The Baker Mfg. Co.

J. T. Suddith & Co.
403 N. 24th St.
Solvay Sales Corporation

Sullivan Machinery Co.
2108 Fifth Ave., North

John D. Turner Company
921-922 Pioneer Bldg.
Barber-Greene Co.
The Universal Crane Co.

The Young & Vann Supply Co.
1725-31 First Ave.
The Philip Carey Company

Dothan

W. L. Andress Motor Co.
Ditwiler Manufacturing Co.

Mobile

Lawrence-Goodling Co., Inc.
161-165 No. Water St.
Cleveland Tractor Co.
The Galion Iron Works & Mfg. Co.

Turner Supply Company
St. Louis & Commerce Sts.
Domestic Engine & Pump Co.
Metal Forms Corporation
G. H. Williams Company

Montgomery

Southern Tractor Co.
405-407 Lee St.
The Baker Mfg. Co.
The Grasselli Chemical Co.
Heltzel Steel Form & Iron Co.

John D. Turner
The Universal Crane Co.

Arizona

Globe

Globe Hardware Co.
Sullivan Machinery Co.

Phoenix

Arizona Tractor & Equip. Co.
238 West Jefferson St.
Harnischfeger Corporation
The Heil Company
Littleford Bros.

Hoeppner Elec. & Mach. Co.
5th and Jefferson Sts.
O. K. Clutch & Machinery Co.

International Harvester Co. of America, Inc.

Pratt-Gilbert Co.
Heltzel Steel Form & Iron Co.

O. S. Stapley Co.
Western Wheeled Scraper Co.

E. D. Tway
1541 E. Van Buren St.
The Cleveland Tractor Co.

Tucson

O'Rielly Motor Co.
Ditwiler Manufacturing Co.

Arkansas

Ft. Smith

Dyke Bros.
South Ninth and D Sts.
The Philip Carey Company

Little Rock

Arkansas Road Equipment Co.
214 West 2nd St.
Metal Forms Corporation

O. B. Avery Company
910 Rector Bldg.
Butler Bin Company
G. H. Williams Company

Dixie Culvert Mfg. Co.
Armco Culvert Mfrs. Association

C. D. Edwards Mfg. Co., Inc.
417 East Markham St.

Fallon & Schnelle, Inc.
825 Home Insurance Bldg.
Sullivan Machinery Co.

Fischer Cement & Roofing Co.
1115-1121 East Second St.
The Philip Carey Company

Fones Bros. Hardware Co.
Second and Rock Sts.
Western Wheeled Scraper Co.

International Harvester Co. of America, Inc.

Joe Lyons Machinery Co.
112 N. Louisiana St.
George Haiss Mfg. Co., Inc.
Ryan Manufacturing Corporation

O'Neal & Kern
2800 West 15th St.
Harnischfeger Corporation

Turner-Shannon Co.
320 E. Markham St.
Ditwiler Manufacturing Co.

Frank Wriggle
Williams Patent Crusher & Pulverizer Co.

California

Bakersfield

A. F. Stoner Company
1681 Chester Ave.
The Cleveland Tractor Co.

Chico

G. B. Troxel
The Cleveland Tractor Co.

Dinuba

Dinuba Garage
The Cleveland Tractor Co.

Eureka

Fred H. Lundblade Co.
Fourth and H Sts.
The Cleveland Tractor Co.

Fillmore

Mack Wooldridge Co.
The Cleveland Tractor Co.

Livermore

E. F. Aylward
The Cleveland Tractor Co.

Los Angeles

E. P. Bosbyshell Co.
Western Wheeled Scraper Co.

The Brown-Bevis Co., Inc.
470 East Third St.
The Burch Corporation
George Haiss Mfg. Co., Inc.
Littleford Bros.
Sullivan Machinery Co.

Celite Products Company
1320 South Hope St.

Collins-Kay Machinery Co.
438 East Third St.
The Fate-Root-Heath Co.

Concrete Machy. & Supply Co.
2014 Santa Fe Ave.
Bucyrus-Erie Company
Butler Bin Company
Domestic Engine & Pump Co.
G. H. Williams Company

C. D. Edwards Mfg. Co., Inc.
Santa Fe Ave. at 14th St.

A. E. Garnjost
824 San Fernando Bldg.
Alan Wood Iron & Steel Co.

Harnischfeger Corporation
2036 Santa Fe Ave.

Harron, Rickard & McCone
2205 Santa Fe Ave.
Ersted Manufacturing Co.
Keystone Driller Company

B. Hayman Company, Inc.
1918 East Seventh St.
Belle City Mfg. Co.

H. Hoffman
523 S. Los Angeles St.
Williams Patent Crusher & Pulverizer Co.

Ingersoll-Rand Co. of Calif.
1460 East Fourth St.

International Harvester Co. of America, Inc.

Kittoe and Hardiman
900 E. Jefferson St.
O. K. Clutch & Machinery Co.

Langlois Bros.
717 So. San Pedro St.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

The Pittsburgh Plate Glass Co.

C. W. Powell
307 E. Third St.
The Buffalo-Springfield Roller Co.

Leigh M. Railsback
115-119 S. Los Angeles St.
Bay City Dredge Works
The Galion Iron Works & Mfg. Co.
Orton Crane & Shovel Co.

Shepherd-Crook Company
514 W. 12th St.
The Baker Mfg. Co.

Six Wheels, Inc.
1223-33 Santa Fe Ave.
The Heil Company

Smith-Booth-Usher Co.
228 Central Ave.
Acme Road Machinery Co.
Barber-Greene Company
Heltzel Steel Form & Iron Co.
Hercules Motors Corporation
Sauerman Bros., Inc.

Southern California Fence Co., Inc.
3651 Whittier Bldg.
Page Steel & Wire Co.

Standard Auto Body Works
1501 Central Ave.
Hydraulic Hoist Mfg. Co.

Sullivan Machinery Co.
412 East Third St.

Warren & Bailey Co.
214-216 E. Third St.
The Philip Carey Company

Western Wholesale Drug Co.
2nd and Los Angeles Sts.
Solvay Sales Corporation

Wickwire Spencer Steel Co.
1070 N. Alameda St.

Mack Wooldridge Co.
219 N. Los Angeles St.
The Cleveland Tractor Co.

Marysville

E. W. Swain
300 E St.
The Cleveland Tractor Co.

Merced

W. H. Senn
252 Nineteenth St.
The Cleveland Tractor Co.

Modesto

Thompson Implement Co.
916-918 F St.
The Cleveland Tractor Co.

Oakland

J. I. Case Threshing Mach. Co.

Cochran & Celli
417 Sixth St.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

C. D. Edwards Mfg. Co., Inc.
2306 Fruitvale Ave.

E. L. Hall
5617 San Pablo Ave.
The Cleveland Tractor Co.

Ransome Company
4030 Hollis St.
Metal Forms Corporation

Spears-Wells Machinery Co.
Ninth and Cedar Sts.
The Buffalo-Springfield Roller Co.

Pomona

H. F. Markham, Inc.
177 W. Commercial St.
The Cleveland Tractor Co.

Porterville

J. C. Doyle Company
227 Main St.
The Cleveland Tractor Co.

Redlands

Redlands Tractor & Implement Co.
615 Orange St.
The Cleveland Tractor Co.

Riverside

C. Lisle Stalder
1230 Main St.
The Cleveland Tractor Co.

Sacramento

Allyn L. Burr Company
11th and R St. (P. O. Box 846)
The Philip Carey Company

R. E. Howell
916 Twentieth St.
The Cleveland Tractor Co.

Salinas

Dean Tractor & Implement
15 Central Ave.
The Cleveland Tractor Co.

San Diego

Machinery Pipe & Supply Co.
Harnischfeger Corporation

International Harvester Co. of America, Inc.

San Francisco

A. B. Ambler
444 Market St.
Alan Wood Iron & Steel Co.

Edward R. Bacon Company
Folsom at 17th St.
Acme Road Machinery Co.
The Baker Mfg. Co.
The Burch Corporation
Hercules Motors Corporation

Blaw-Knox Company
411 Matson Bldg.

Bucyrus-Erie Company
433 California St.

Celite Products Company
140 Spear St.

Dieterich-Post Co.
75 New Montgomery St.
Buff & Buff Mfg. Co.

Engineering & Sales Co.
555 Howard St.
Perfex Corporation

Garfield & Company
1232 Hearst Bldg.
Bucyrus-Erie Company
The Fate-Root-Heath Co.
G. H. Williams Company

Harnischfeger Corporation
32 Beale St.

Harron, Rickard & McCone
139 Townsend St.
Ersted Manufacturing Co.
Keystone Driller Company
Littleford Bros.

Geo. Herrmann Co.
300 Front St.
Solvay Sales Corporation

Honolulu Iron Works
215 Market St.
Harnischfeger Corporation

Ingersoll-Rand Co. of Calif.
Rialto Bldg.

International Harvester Co. of America, Inc.

Jones Bros. Asbestos Supply Co., Inc.
500 Second St.
The Philip Carey Company

Michel & Pfeffer Iron Works
Harrison and Tenth Sts.
Page Steel & Wire Co.

Modern Vehicle Co.
437 Fourth St.
The Heil Company

Nugent Covey Wagon Co.
53 Duboce Ave.
Hydraulic Hoist Mfg. Co.

The Pittsburgh Plate Glass Co.

Smith-Booth-Usher Co.
50 Fremont St.
Barber-Greene Company
Butler Bin Company
Sauerman Bros., Inc.

Robert A. Smith, Inc.
399 Golden Gate Ave.
Ditwiler Manufacturing Co.

Stuart S. Smith
19th and Indiana Sts.
The Galion Iron Works & Mfg. Co.
O. K. Clutch & Machinery Co.
Orton Crane & Shovel Co.

Sullivan Machinery Co.
582 Market St.

United Commercial Co.
837 Merrill Ave.
Western Wheeled Scraper Co.

Wickwire Spencer Steel Co.
144 Townsend Street

Williams Patent Crusher & Pulverizer Co.
415 Fifth St.

A. L. Young Machy. Co.
26 Fremont St.
E. D. Etnyre & Co.
George Haiss Mfg. Co., Inc.

San Jose

Dean Tractor & Implement
269 W. Santa Clara St.
The Cleveland Tractor Co.

Santa Ana

May-Bemis Company
311 W. Fifth St.
The Cleveland Tractor Co.

Santa Rosa

Steiner & Yandle
The Cleveland Tractor Co.

Stockton

San Joaquin Tractor Company
Market and Aurora Sts.
The Cleveland Tractor Co.

The H. C. Shaw Company
The Roderick Lean Company

Ukiah

Steiner & Yandle
The Cleveland Tractor Co.

Ventura

Mack & Wooldridge Co.
825 Santa Clara St.
The Cleveland Tractor Co.

Visalia

W. J. Woodard
509 E. Main St.
The Cleveland Tractor Co.

Watsonville

Dean Tractor & Implement Co.
The Cleveland Tractor Co.

West Berkeley

California Corrugated Culvert Co.
Armco Culvert Mfrs. Association

Whittier

Edward Keasbey
234 S. Greenleaf Ave.
The Cleveland Tractor Co.

Colorado

Denver

Burnite Machinery Co.
Boston Bldg.
George Haiss Mfg. Co., Inc.
Orton Crane & Shovel Co.

J. I. Case Threshing Mach. Co.

Celite Products Company
Symes Bldg.

Clinton & Held Company
1501 Wazee St.
The Baker Mfg. Co.
The Roderick Lean Company

Denver Fire Clay Co.
1742 Champa St.
Solvay Sales Corporation

C. D. Edwards Mfg. Co., Inc.
1525 Sixteenth St.

Paul Fitzgerald
U. S. Nat'l Bank Bldg.
The Fate-Root-Heath Co.
Harnischfeger Corporation

The R. Hardesty Mfg. Co.
Armco Culvert Mfrs. Association

International Harvester Co. of America, Inc.

Lallie Surveying Instrument Co.
719 Eighteenth St.
Buff & Buff Mfg. Co.

Liberty Trucks & Parts Co.
1532 Sixteenth St.
The Cleveland Tractor Co.

H. W. Moore Equipment Co.
Sixth and Acoma Sts.
Bay City Dredge Works.
E. D. Etnyre & Co.
The Galion Iron Works & Mfg. Co.
Hercules Motors Corporation
The Universal Crane Co.

A. G. Olds
First National Bank Bldg.
Williams Patent Crusher & Pulverizer Co.

H. G. Sanford
1201 Jackson St.
Keystone Driller Company

Standard Sanitary Mfg. Co.
1730 Blake St.
The Philip Carey Company

Stearns-Roger Mfg. Co.
1718 California St.
Ingersoll-Rand Co.
Page Steel & Wire Co.

Herbert Steinbarger Co.
1642-46 Wazee St.
Bucyrus-Erie Company
The Buffalo-Springfield Roller Co.
Domestic Engine & Pump Co.
Metal Forms Corporation
Sauerman Bros., Inc.
G. H. Williams Company

Sullivan Machinery Co.
836 Equitable Bldg.

Timpte Brothers
3rd at Market St.
Hydraulic Hoist Mfg. Co.

Wilson Machinery Company
1936 Market St.
Barber-Greene Company
The Heil Company
Rawls Manufacturing Co.
Sullivan Machinery Co.
Western Wheeled Scraper Co.

Winter-Weiss Company
620 Broadway
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

Connecticut

Hartford

Ingersoll-Rand Co. of New England
482 Ann St.

K. B. Noble Company
247 Pearl St.
Hercules Motors Corporation
Sullivan Machinery Co.

New Haven

Arthur Caplan
P. O. Box 257
Bay City Dredge Works

W. I. Clark Company
217 Lafayette St.
Barber-Greene Company
Harnischfeger Corporation
Metal Forms Corporation

Gesner Contractors Equipment Co.
254 Park St.
Domestic Engine & Pump Co.
Heltzel Steel Form & Iron Co.
Littleford Bros.

International Harvester Co. of America, Inc.

Power Equipment & Service, Inc.
47 Hill St.
The Cleveland Tractor Co.
The Roderick Lean Company

The John P. Smith Co.
501 State St.
Page Steel & Wire Co.

West Hartford

W. I. Clark Company
Flagg Road
Barber-Greene Company

Delaware

Wilmington

The Pittsburgh Plate Glass Co.

District of Columbia

Washington

Asbestos Covering & Roofing Co.
916-918 D St., N. W.
The Philip Carey Company

Concrete Steel Company
2525 Pennsylvania Ave., N. W.
Hoosier Asphalt Company

General Auto Truck Co.
21st St. and Virginia Ave.
The Heil Company

Hudson Supply & Equip. Co.
917 15th St., N. W.
Hercules Motors Corporation

Ingersoll-Rand Co.
Munsey Bldg.

W. Newton Jeffress, Inc.
891 National Press Bldg.
Rawls Manufacturing Co.

S. J. Meeks' Son
622 G St., N. E.
Hydraulic Hoist Mfg. Co.

The Henry H. Meyer Co.
Domestic Engine & Pump Co.

Paul D. Osmond
1245 Wisconsin Ave., N. W.
The Heil Company

Witt Will Company
52 N St., N. E.
Hydraulic Hoist Mfg. Co.

Florida

Daytona

Austin-Western Road Machinery Co.
Western Wheeled Scraper Co.

Ft. Lauderdale

O. Th. Carpentier
P. O. Box 1938
Williams Patent Crusher & Pulverizer Co.

Jacksonville

Austin-Western Road Machinery Co.
8 Riverside Viaduct
Western Wheeled Scraper Co.

The Cameron & Barkley Co.
605 E. Forsyth St.
The Philip Carey Company

Chapman Cge. Works
P. O. Box 723, 116 Hogan St.
Ditwiler Manufacturing Co.

Concrete Steel Company
P. O. Box 2581
Hoosier Asphalt Company

Construction Equipment Co.
437 East Bay St.
Heltzel Steel Form & Iron Co.
Sauerman Bros., Inc.

Contractors Equipment Co.
18 Riverside Viaduct
Butler Bin Company

Z. T. Darrow & Son
919 W. Bay St.
Keystone Driller Company

H. & W. B. Drew Company
Buff & Buff Mfg. Co.

R. G. Enell
321 E. 19th St.
Fruehauf Trailer Company

Harnischfeger Corporation
509 E. Eighth St.

International Harvester Co. of America, Inc.

Jacksonville Supply Co.
408 E. Bay St.
Page Steel & Wire Co.

McDonald & Burgman
8 Riverside Viaduct
Bucyrus-Erie Company
The Universal Crane Co.
G. H. Williams Company

M. D. Moody
402 Masonic Temple
American Tar Products Co.
The Buffalo-Springfield Roller Co.
E. D. Etnyre & Co.
Littleford Bros.
Rawls Manufacturing Co.

The Pittsburgh Plate Glass Co.

Reynolds Machinery Co.
W. Bay St.
Acme Road Machinery Co.

W. H. Titus
502 Barnett Bldg.
Barber-Greene Company

Miami

Austin-Western Road Machy. Co.
1030 N. Miami Ave.
Western Wheeled Scraper Co.

The Cameron & Barkley Co.
127-129 N. W. Fifth St.
The Philip Carey Company

Contractors Equipment Co.
2315 N. Miami Ave.
Butler Bin Company

M. H. Elder & Co.
93 N. E. 20th St.
O. K. Clutch & Machinery Co.
Sullivan Machinery Co.

General Machinery Equip. Co.
116 N. E. 6th St.
Acme Road Machinery Co.
Domestic Engine & Pump Co.
The Good Roads Machinery Co.
George Haiss Mfg. Co., Inc.
Ryan Manufacturing Corporation

E. F. Holmes
37 N. W. 3rd Ave.
Heltzel Steel Form & Iron Co.

International Harvester Co. of America, Inc.

L. D. Llewellyn, Inc.
1031 N. Miami Ave.
Barber-Greene Company
The Cleveland Tractor Co.
Metal Forms Corporation

McDonald & Burgman
2315 N. Miami Ave.
Bucyrus-Erie Company
G. H. Williams Company

The Pittsburgh Plate Glass Co.

D. E. Rossetter
1216 Ingraham Bldg.
Buff & Buff Mfg. Co.

Orlando

The Galion Iron Works & Mfg. Co.
1207-09 Virginia Drive

St. Petersburg

Pinellas Ptg. & Stationery Co.
Buff & Buff Mfg. Co.

Tampa

Burress-Clark Mach. Co.
Morgan and Hampton Sts.
Butler Bin Company
George Haiss Mfg. Co., Inc.

The Cameron & Barkley Co.
South Franklin St., P. O. Box 717
The Philip Carey Company

Charles Hovey, Inc.
Box 3149
Solvay Sales Corporation

F. L. Kearney & Co.
P. O. Box 557
Sullivan Machinery Co.

McDonald & Burgman
P. O. Box 4497
G. H. Williams Company

C. W. McDonald
Bucyrus-Erie Company

Ogden Machinery Co., Inc.
17th St. and 1st Ave.
Acme Road Machinery Co.
Barber-Greene Company
Domestic Engine & Pump Co.
Metal Forms Corporation

Smith Chevrolet Co.
1554 Franklin St.
Ditwiler Manufacturing Co.

Wilson Oil Equipment Co.
803 Wallace S. Bldg.
The Heil Company

Woodward-Wight & Co., Ltd.
Ersted Manufacturing Co.

West Palm Beach

Contractors Equipment Co.
Butler Bin Company

Halsey & Griffith
Buff & Buff Mfg. Co.

Georgia

Albany

Yancey Tractor Co.
109-115 Booker Ave.
The Baker Mfg. Co.
George Haiss Mfg. Co., Inc.
Harnischfeger Corporation

Atlanta

Edgar Alexander, Inc.
501-503 Whitehall St.
Heltzel Steel Form & Iron Co.
Rawls Manufacturing Co.

R. S. Armstrong & Bro. Co.
676 Marietta St.
Butler Bin Company
Domestic Engine & Pump Co.

Atlanta Blue Print Co.
96 Walton St.
Buff & Buff Mfg. Co.

W. E. Austin Machy. Co.
128 Marietta St.
Sullivan Machinery Co.

Bucyrus-Erie Company
1021 Healey Bldg.

Campbell Coal Company
Marietta at Foundry St.
P. O. Box 1498
The Philip Carey Company

The Philip Carey Company
411-412 Bona Allen Bldg.
P. O. Box 1227

J. I. Case Threshing Mach. Co.

The Dixie Culvert & Metal Co.
Armco Culvert Mfrs. Association

Drennen & Zahn
449 Marietta St.
Hydraulic Hoist Mfg. Co.

C. D. Edwards Mfg. Co., Inc.
Walker St., Corner Haynes

M. H. Elder Culvert & Machy. Co.
647 Whitehall St., S. W.
The Cleveland Tractor Co.
The Galion Iron Works & Mfg. Co.

D. B. Frisbie
1021 Healy Bldg.
Barber-Greene Company

Good Roads Machinery Co.
The Jos. Honhorst Co.

Harnischfeger Corporation
1050 Ponce de Leon Apartments

Hercules Sales Co.
385½ Whitehall St., S. W.
Ditwiler Manufacturing Co.

Ingersoll-Rand, Inc.
1102 Candler Bldg.

International Harvester Co. of America, Inc.

W. A. Neal & Son, Inc.
137 Marietta St.
The Universal Crane Co.

The Pittsburgh Plate Glass Co.

Solvay Sales Corporation
101 Marietta St.

Tractor & Machinery Co.
351 Whitehall St.
The Good Roads Machinery Co.

Western Wheeled Scraper Co.
602 Rhodes Bldg.

J. R. Whitman
705 Bona Allen Bldg.
Page Steel & Wire Co.

Williams-Small Machy. Co.
205 Walton Bldg.
O. K. Clutch & Machinery Co.

E. L. Williamson
835 Juniper St., N. E.
Bay City Dredge Works.

Yancey Bros.
634 Whitehall St.
Acme Road Machinery Co.
The Baker Mfg. Co.
The Buffalo-Springfield Roller Co.
The Grasselli Chemical Co.
George Haiss Mfg. Co., Inc.
Harnischfeger Corporation
Hercules Motors Corporation

Macon

Swasey-Taylor Equip. Co.
501 Macon Nat'l Bank Bldg.
The Fate-Root-Heath Co.

Savannah

A. B. Moore, Jr.
Arcade Bldg.
Barber-Greene Company

The Pittsburgh Plate Glass Co.

Savannah Iron & Wire Works
N. W. Cor. Liberty and Houston Sts.
Page Steel & Wire Co.

Stewart Mongeau Motor Co.
213 Broughton St., N. E.
Hydraulic Hoist Mfg. Co.

Thomasville

W. A. Neal & Son, Inc.
325 E. Jackson St.
The Universal Crane Co.

Idaho

Boise

E. L. Blake Company
Box 634
O. K. Clutch & Machinery Co.

Burnham Manufacturing Co.
Page Steel & Wire Co.

Howard-Cooper Corporation
Box 1305
Barber-Greene Company

Illinois

Aurora

International Harvester Co. of America, Inc.

Bloomington

Tracy Green, Inc.
Ditwiler Manufacturing Co.

Cairo

International Harvester Co. of America, Inc.

Chicago

Acme Road Machinery Co.
160 N. La Salle St.

R. D. Allrich
2045 Arthur Ave.
Metal Forms Corporation

A. J. Alsdorf Corporation
(Foreign Agent)
The Jos. Honhorst Co.

H. P. Andresen & Co. (Snow Plows)
4450 Ravenswood Ave.
The Baker Mfg. Co.

Barber-Greene Company
9 South Clinton St.

The Barrett Company
2800 S. Sacramento Ave.
P. O. Box 1082

Blaw-Knox Company
Peoples Gas Bldg.

Bohan and Company
112 West Adams St.
O. K. Clutch & Machinery Co.

Bucyrus-Erie Company
134 S. LaSalle St.

Celite Products Company
225 E. Superior Street

Chicago Fence & Wire Co.
4400 Addison Blvd.
Page Steel & Wire Co.

Chicago Tractor Equip. Co.
946 West Huron St.
The Roderick Lean Company

Concrete Steel Company
Monadnock Block
Hoosier Asphalt Company

Dravo Equipment Co.
611-613 West Fulton St.
Hercules Motors Corporation

E. H. Edwards
227 West Austin Ave.
The Buffalo-Springfield Roller Co.

Erlinder-Platt Body Corp.
40th and Wabash Ave.
Ditwiler Manufacturing Co.

The Good Roads Machy. Co., Inc.
4860 S. Halsted St.
Rawls Manufacturing Co.
Ryan Manufacturing Corporation.

Harnischfeger Corporation
1639-40 Monadnock Building

The Heil Company
2422 Cottage Grove Ave.

R. H. Hyland Company
221 West Huron St.
G. H. Williams Company

Illinois Philip Carey Co.
2100 Fullerton Ave.
The Philip Carey Company

Ingersoll-Rand Co. of Ill.
360 North Michigan Blvd.

International Harvester Co. of America, Inc.

Jacob Press' Sons
501 West 33rd St.
Hydraulic Hoist Mfg. Co.

Keystone Driller Company
53 West Jackson Blvd.

W. B. Louer Company
431-435 S. Jefferson St.
The Baker Mfg. Co.
Hercules Motors Corporation

The G. F. Lowe Co.
612 N. Michigan Ave.
Bay City Dredge Works
George Haiss Mfg. Co., Inc.

R. N. Lowry & R. M. Nelson
122 S. Michigan Ave.
The Fate-Root-Heath Co.

Mead-Morrison Mfg. Co.
Monadnock Block

Midwest Tractor & Equipment Co.
4860 S. Halsted St.
The Cleveland Tractor Co.

The Pittsburgh Plate Glass Co.

T. C. Prince
2711 S. Wabash Ave.
Fruehauf Trailer Company

Sieg-Warford Company
Lee Trailer & Body Co.

Solvay Sales Corporation
112 West Adams St.

Sullivan Machinery Co.
429 Peoples Gas Bldg.

Superior Supply Company
Kostner Ave. at 19th St.
Butler Bin Company
Heltzel Steel Form & Iron Co.
Sullivan Machinery Co.

Thaleg & Hook, Inc.
236 N. Clark St.
Western Crucible Steel Casting Co.

I. P. Treutelaar
916 Strauss Bldg.
Asphalt Brick Company

Western Contractors Supply Co.
14 N. Clinton St.
Domestic Engine & Pump Co.

Western Wheeled Scraper Co.
29 S. LaSalle St.

Wickwire Spencer Steel Co.
208 S. La Salle Street

G. H. Williams Company
1019 Monadnock Bldg.

Williams Patent Crusher & Pulverizer Co.
37 West Van Buren St.

Decatur

Wm. Frede & Son
Ditwiler Manufacturing Co.

East St. Louis

International Harvester Co. of America, Inc.

Joliet

International Harvester Co. of America, Inc.

Kankakee

International Harvester Co. of America, Inc.

McLeansboro

Graff & Hyatt
The Galion Iron Works & Mfg. Co.

Moline

Auto Service Company
Ditwiler Manufacturing Co.

Oak Park

H. A. Lamb
237 S. Maple Ave.
G. H. Williams Company

Peoria

Business Equipment Co.
120 S. Jefferson Ave.
Buff & Buff Mfg. Co.

J. I. Case Threshing Mach. Co.

C. D. Edwards Mfg. Co., Inc.
908 Leahman Bldg.

A. E. Hudson Company
Western Crucible Steel Casting Co.

International Harvester Co. of America, Inc.

Thayer K. Morrow, Inc.
Ditwiler Manufacturing Co.

Peoria Builders Supply Co.
100 Cedar St.
O. K. Clutch & Machinery Co.

Quincy

International Harvester Co. of America, Inc.

Rockford

International Harvester Co. of America, Inc.

A. H. Puffer
The Galion Iron Works & Mfg Co.

Springfield

International Harvester Co. of America, Inc.

W. Q. O'Neall Company
Armco Culvert Mfrs. Assn.

Geo. F. Smith Co.
1737 Lowell Ave.
The Universal Crane Co.

Streator

Rawls Manufacturing Co.
202-210 Iowa Ave.

Indiana

Crawfordsville

The W. Q. O'Neall Company
Armco Culvert Mfrs. Assn.

Evansville

Crescent City Supply Co.
O. K. Clutch & Machinery Co.

International Harvester Co. of America, Inc.

Power Farming Equip. Co.
The Roderick Lean Company

The Vulcan Plow Co.
The Roderick Lean Company

Fort Wayne

Coan Equipment Co.
236 Murray St.
Bay City Dredge Works
Harnischfeger Corporation

Cockrell Tractor Company
1215 Buchanan St.
The Baker Mfg. Co.

Ft. Wayne Pipe & Supply Co.
225 E. Columbia St.
Hercules Motors Corporation

International Harvester Co. of America, Inc.

Moellering Supply Co.
241 Murray St.
O. K. Clutch & Machinery Co.

Truck Engineering Co.
Hydaulic Hoist Mfg. Co.

Gary

International Harvester Co. of America, Inc.

Indianapolis

Allied Truck Equipment Co.
730 E. Washington St.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

Bock Equipment Co.
1900 Northwestern Ave.
Sullivan Machinery Co.

The Philip Carey Company
740 E. North St., (P.O. Box 1004)

J. I. Case Threshing Mach. Co.

William F. Cleary
O. K. Clutch & Machinery Co.

Crawler Tractor & Equip. Co.
305 Merchant Bank Bldg.
The Cleveland Tractor Co.

S. H. Edlin & Son
20 S. Senate Ave.
Domestic Engine & Pump Co.

Deane P. Harber
Golden Hill
Fruehauf Trailer Company

Harnischfeger Corporation
808 Guaranty Bldg.

William Hayes
The Burch Corporation

W. J. Holliday & Co.
Ersted Manufacturing Co.

Hooper Equipment Co.
224 N. Alabama St.
Belle City Mfg. Co.

The Hoosier Fence Co.
1660 Astor St.
Page Steel & Wire Co.

International Harvester Co. of America, Inc.

Kiger & Company
113 S. Pennsylvania St.
The Galion Iron Works & Mfg. Co.

Knox Engineering & Equip. Co.
32 North Senate Ave.
Bay City Dredge Works
Rawls Manufacturing Co.

H. Lieber Company
24 W. Washington St.
Buff & Buff Mfg. Co.

W. T. MacDonald & Co.
1041 W. 25th St.
Barber-Greene Company
Heltzel Steel Form & Iron Co.
G. H. Williams Company

C. F. Messenger
3015 North Meridian St.
Butler Bin Company
Metal Forms Corporation

Perry & Wilson Equip. Co.
345 E. South St.
The Baker Mfg. Co.
George Haiss Mfg. Co., Inc.

O. F. Schlensker
4290 N. Illinois St.
Hydraulic Hoist Mfg. Co.

Shearer & Mayer
P. O. Box 285
Sauerman Bros., Inc.

Solvay Sales Corporation
709 Guaranty Bldg.

Logansport

The Municipal Supply
2533 Broadway
Rawls Manufacturing Co.

Marion

Superior Body Corporation
Hydraulic Hoist Mfg. Co.

Richmond

International Harvester Co. of America, Inc.

South Bend

International Harvester Co. of America, Inc.

Terre Haute

C. D. Edwards Mfg. Co., Inc.
13½ and C. & E. I. R. R.

International Harvester Co. of America, Inc.

Kintz Service & Mfg. Co.
Hydraulic Hoist Mfg. Co.

Iowa

Cedar Falls

International Harvester Co. of America, Inc.

Cedar Rapids

International Harvester Co. of America, Inc.

Council Bluffs

International Harvester Co. of America, Inc.

Davenport

Allen R. Boudinot
904 E. 14th St.
Fruehauf Trailer Co.

Carleton Motor Company
417 W. 3rd St.
Hydraulic Hoist Mfg. Co.

Gierke-Robinson Co.
322 W. Fourth St.
The Cleveland Tractor Co.
The Jos. Honhorst Co.
Sullivan Machinery Co.

C. H. Hubbell
2218 Harrison St.
George Haiss Mfg. Co., Inc.
Littleford Bros.

International Harvester Co. of America, Inc.

Johnson-Beckwith Equip Co.
524 Union Davenport Bank Bldg.
Harnischfeger Corporation
Metal Forms Corporation
Rawls Manufacturing Co.

Des Moines

Badger Body Mfg. Co.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

Herman M. Brown Company
212-216 Twelfth St.
Barber-Greene Company
Ersted Manufacturing Co.
Ryan Manufacturing Corp.

J. I. Case Threshing Mach. Co.

Des Moines Steel Company
421 S. W. 4th St.
Page Steel & Wire Co.

The Galion Iron Works & Mfg Co.
117-119 W. Eleventh St.

Globe Mach. & Supply Co.
205 W. Court Ave.
Bucyrus-Erie Company
George Haiss Mfg. Co., Inc.
Heltzel Steel Form & Iron Co.
Sullivan Machinery Co.
G. H. Williams Company

Harnischfeger Corporation
302 Hubbell Bldg.

International Harvester Co. of America, Inc.

Iowa Machy. & Supply Co.
317 West Court St.
O. K. Clutch & Machinery Co.

Iowa Pure Iron Company
Armco Culvert Mfrs. Assn.

Power Equipment Company
1725 W. Grand Ave.
Belle City Mfg. Co.

Weston Dump Body Co.
326 S. W. 11th St.
Hydraulic Hoist Mfg. Co.

Dubuque

C. R. Considine
1022 Langworthy St.
Williams Patent Crusher & Pulverizer Co.

International Harvester Co. of America, Inc.

Ft. Dodge

International Harvester Co. of America, Inc.

Mason City

Independence Corrugated Culvert Company
Armco Culvert Mfrs. Assn.

International Harvester Co. of America, Inc.

Sioux City

International Harvester Co. of America, Inc.

Steffen-Van Steenwyk Co.
612 W. Seventh St.
The Heil Company

Frank T. Wilson
613 Water St.
Hydraulic Hoist Mfg. Co.

Waterloo

International Harvester Co. of America, Inc.

Kansas

Dodge City

Winter-Weiss Co.
Ditwiler Manufacturing Co.

Eldorado

Mountain Iron & Supply Co.
Domestic Engine & Pump Co.

Great Bend

E. E. Cook
The Cleveland Tractor Co.

Hutchinson

J. A. Fox Tractor Co.
16 E. Third St.
The Cleveland Tractor Co.

International Harvester Co. of America, Inc.

Kansas City

Solvay Sales Corporation
Finance Bldg.

Parsons

International Harvester Co. of America, Inc.

Pittsburg

Marshall Supply Co.
Sullivan Machinery Co.

Salina

International Harvester Co. of America, Inc.

Topeka

International Harvester Co. of America, Inc.

Wallace McKenzie
Western Wheeled Scraper Co.

The Road Supply & Metal Co.
Armco Culvert Mfrs. Assn.

Wichita

H. W. Cardwell Co., Inc.
300 S. Wichita St.
The Baker Mfg. Co.

Jack Cooper & Bro.
Ditwiler Manufacturing Co.

International Harvester Co. of America, Inc.

Snider Motor Service
210 S. Wichita St.
The Cleveland Tractor Co.

Kentucky

Covington

Stewart Iron Works
Hydraulic Hoist Mfg. Co.

Lexington

International Harvester Co. of America, Inc.

J. W. Kemper
The Good Roads Machinery Co.

W. C. Siedner
375 Park Ave.
The Burch Corporation
E. D. Etnyre & Co.

B. B. Wilson Company
139-151 N. Mill St.
The Cleveland Tractor Co.

Louisville

Thos J. Barret
112-114 S. Second St.
Acme Road Machinery o.
George Haiss Mfg. Co., Inc.
Metal Forms Corporation
O. K. Clutch & Machinery Co.
Ryan Manufacturing Corp.
G. H. Williams Company

Brandeis Mach. & Supply Co.
325 W. Main St.
Barber-Greene Company
Bucyrus-Erie Company
The Buffalo-Springfield Roller Company
Domestic Engine & Pump Co.
The Fate-Root-Heath Co.
Littleford Bros.
Sauerman Bros., Inc.
Western Wheeled Scraper Co.

Chevrolet Truck Sales Corp.
740-744 S. 1st St.
Ditwiler Manufacturing Co.

G. E. Compton
628 Jefferson St.
E. D. Etnyre & Co.

Electric Blue Print & Supply Co.
306 West Walnut St.
Buff & Buff Mfg. Co.

International Harvester Co. of America, Inc.

Kentucky Culvert Mfg. Co.
Armco Culvert Mfrs. Assn.

Walter L. Lacy Co., Inc.
1032-1044 S. Eighth St.
The Philip Carey Company

Logan Company
1115 Franklin St.
Page Steel & Wire Co.

The Pittsburgh Plate Glass Co.

Sid. Schultze
217 Guthrie St.
The Heil Company
Hydraulic Hoist Mfg. Co.

Roy C. Wayne Supply Co.
608 W. Jefferson St.
The Baker Mfg. Co.
Heltzel Steel Form & Iron Co.
Hercules Motors Corporation
The Jos. Honhorst Co.
Sullivan Machinery Co.

Middlesboro

Reams Hardware Co.
Sullivan Machinery Co.

Morganfield

Tucker & Tucker
The Cleveland Tractor Co.
Western Wheeled Scraper Co.

Paducah

Olcott Grinding & Machine Co.
122 Kentucky Ave.
Hydraulic Hoist Mfg. Co.

H. A. Petter Supply Co.
Domestic Engine & Pump Co.

Louisiana

Alexandria

Brown Roberts Hardware Co.
Western Wheeled Scraper Co.

Baton Rouge

Louisiana Corrugated Culvert Co.
Armco Culvert Mfrs. Assn.

New Orleans

John A. Abele
P. O. Box 682
Orton Crane & Shovel Co.

The Barrett Company
1640 Gravier St.

The Philip Carey Company
P. O. Box 1009

Celite Products Company
409 Whitney Central Bank Bldg.

J. J. Clarke Company, ltd.
Julia and Magnolia Sts.
P. O. Box 900
The Philip Carey Company

Clyde Company, Inc.
309 Magazine St.
Barber-Greene Company
Butler Bin Company
Sauerman Bros., Inc.
Sullivan Machinery Co.
The Universal Crane Co.

Equitable Equipment Co.
410 Camp St.
The Fate-Root-Heath Co.
Keystone Driller Company

Hercules Sales Co.
614 North Rampart St.
Ditwiler Manufacturing Co.

Ingersoll-Rand, Inc.
1707 Hibernia Bank Bldg.

International Harvester Co. of America, Inc.

Louisiana Road Machinery Co.
1111 Julia St.
The Buffalo-Springfield Roller Company

Morrissey-Easton Tractor Co.
Laurel and Lafayette Sts.
The Baker Mfg. Co.

New Orleans B. P. & Supply Co.
826 Union St.
Buff & Buff Mfg. Co.

The Orleans Steel Products Co., Inc.
1025 Bienville St.
Page Steel & Wire Co.

C. T. Patterson Co., Inc.
800 S. Peters St.
Bay City Dredge Works
The Cleveland Tractor Co.
George Haiss Mfg. Co., Inc.
Heltzel Steel Form & Iron Co.

The Pittsburgh Plate Glass Co.

Southern States Equipment Co.
801 New Orleans Bank Bldg.
Domestic Engine & Pump Co.
Harnischfeger Corporation
O. K. Clutch & Machinery Co.
G. H. Williams Company

Stauffer, Eshleman & Co., Ltd.
520 Iberville St.
Domestic Engine & Pump Co.

Truck Equipment Co.
3616 Tulane Ave.
Fruehauf Trailer Company

Woodward Wight & Co.
451 Howard Ave.
Ersted Manufacturing Co.
Solvay Sales Corporation
Western Wheeled Scraper Co.
Williams Patent Crusher & Pulverizer Co.

Wormington & Powers, Inc.
337 Howard Ave.
Littleford Bros.
Metal Forms Corporation

Shreveport

Builders Supply Company
Box 295
Heltzel Steel Form & Iron Co.
O. K. Clutch & Machinery Co.

International Harvester Co. of America, Inc.

Lee Hardware Company
Western Wheeled Scraper Co.

Meriwether Supply Co.
1312 Jordan St.
Page Steel & Wire Co.

Norvell-Wilder Hardware Co.
Hercules Motors Corporation

Shreveport Machy. Sales Co.
927 Giddens-Lane Bldg.
Barber-Greene Company
Bay City Dredge Works

Maine

Bangor

Bangor Mill Supply Co.
O. K. Clutch & Machinery Co.

C. M. Conant Company
182-196 Broad St.
Barber-Greene Company

Brewer

Eastern Motors, Inc.
12 State St.
The Cleveland Tractor Co.

Caribou

Mack Bouchard & Son
The Cleveland Tractor Co.

Portland

Hedge & Mattheis Co.
71 Kennebec St.
Butler Bin Company
Littleford Bros.

International Harvester Co. of America, Inc.

Waldo Bros. & Bond Co.
34 Columbia Road
Sullivan Machinery Co.

Warren Tractors Co.
Forrest Ave. and Kennebec
The Cleveland Tractor Co.

Maryland

Baltimore

Acme Road Machinery Co.
709 Equitable Bank Bldg.

Baltimore Tractor Company
31 South Charles St.
The Cleveland Tractor Co.

The Barrett Company
Mulberry St. & Warwick Ave.

Blaw-Knox Company
Baynard and Warner Sts.

Thos M. Brown
106 South Gay St.
The Burch Corporation
The Grasselli Chemical Co.
Heltzel Steel Form & Iron Co.
Keystone Driller Company
Metal Forms Corporation

The Philip Carey Company
1400 Blk. Moreland Ave. and W. M. Ry.

Celite Products Company
601 Emerson Tower Bldg.

D. C. Elphinstone, Inc.
120 S. Calvert St.
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.

Harnischfeger Corporation
1302 Lexington Bldg.

Hercules Sales Co.
Monroe St. and Elgin Ave.
Ditwiler Manufacturing Co.

Hirshberg Art Company
418 N. Howard St.
Buff & Buff Co.

International Harvester Co. of America, Inc.

The Jewel Supply & Equip Co.
34 S. Calvert St.
Rawls Manufacturing Co.

John C. Louis Co.
221 S. Eutaw St.
Butler Bin Company
The Good Roads Machinery Co.
Littleford Bros.

W. B. McCauley
2125 Lyndhurst Ave.
Barber-Greene Company

Maryland Chemical Co.
Bayard and Russell Sts.
Solvay Sales Corporation

Maryland Culvert & Metal Co.
Armco Culvert Mfrs. Assn.

Maryland Truck Equip. Corp.
Centre and Holliday Sts.
The Heil Company

Henry H. Meyer Co.
110 S. Howard St.
The Baker Mfg. Co.
Domestic Engine & Pump Co.

Peters Auto Body & Spring Works
Hydraulic Hoist Mfg. Co.
Lee Trailer & Body Co.

The Pittsburgh Plate Glass Co.

Horace T. Potts & Co.
504 St. Paul Street
Page Steel & Wire Co.

Massachusetts

Boston

Aberthaw Company
133 Southampton St.
George Haiss Mfg. Co., Inc.

The Barrett Company
11 Beacon St.

A. G. Beal
141 Milk St.
Alan Wood Iron & Steel Co.

Bucyrus-Erie Company
131 State St.

Celite Products Company
79 Milk St.

The Philip Carey Company
98 Cambridge St., Charlestown

Clark-Wilcox Company
786 Albany St.
Metal Forms Corporation

Concrete Steel Company
294 Washington St.
Hoosier Asphalt Company

Thos. D. Connolly
1 Court St.
Bay City Dredge Works

F. T. Curley Co., Inc.
120 High St.
Sullivan Machinery Co.

C. R. Dodge Co.
141 Milk Street
Heltzel Steel Form & Iron Co.

E. D. Etnyre & Co.
11 Beacon St.

C. A. Gates & Company
168 Dartmouth St.
Page Steel & Wire Co.

Globe Machy. & Supply Co.
205 West Court Ave.
Butler Bin Company

Harnischfeger Corporation
194 Boylston St.

Hedge & Mattheis Co.
285 Dorchester Ave.
Butler Bin Company
Littleford Bros.

The Heil Company
298 N. Harvard St., Brighton

Hercules Sales Co. of New York
Ditwiler Manufacturing Co.

Ingersoll-Rand Co. of New England
285 Columbus Ave.

International Harvester Co. of America, Inc.

S. H. Keith
Room 1152—141 Milk St.
Fruehauf Trailer Company

Mead-Morrison Mfg. Co.
257 Prescott St.

New England Road Machinery Co.
The Jos. Honhorst Co.

The Pittsburgh Plate Glass Co.

Power Equipment Co.
131 State St.
G. H. Williams Company

Solvay Sales Corporation
77 Summer St.

Sullivan Machinery Co.
45 Milk St.

Waldo Bros. & Bond Co.
202 Southampton St.
Domestic Engine & Pump Co.
Sullivan Machinery Co.

Cambridge

Acme Road Machinery Co.
85 Broadway

Barber-Greene Company
27 Commercial Ave.

Boston Tractor Company
46 Carleton St.
The Cleveland Tractor Co.

W. H. Dance
61-69 Broadway
O. K. Clutch & Machinery Co.

Dyar Sales & Machy. Co.
66 Broadway
The Baker Mfg. Co.
The Burch Corporation
Western Crucible Steel Casting Co.

Standard Body Company
181 Brookline St.
Hydraulic Hoist Mfg. Co.

Holyoke

H. F. Davies Tractor Co.
54 Montgomery Ave.
The Cleveland Tractor Co.

Lawrence

Edw. E. Curley
264 Essex St.
George Haiss Mfg. Co., Inc.

Palmer

New England Metal Culvert Co.
Armco Culvert Mfrs. Assn.

Springfield

Hedges & Mattheis Co.
62-68 Main St.
Butler Bin Company
Littleford Bros.

International Harvester Co. of America, Inc.

The Pittsburgh Plate Glass Co.

Watertown

Waldo Bros. & Bond Co.
157 Common St.
Sullivan Machinery Co.

Winchester

Waldo Bros. & Bond Co.
12 Park Ave.
Sullivan Machinery Co.

Wollaston

Waldo Bros. & Bond Co.
50 West Elm Ave.
Sullivan Machinery Co.

Worcester

George R. Conyne
123 Stafford St.
Keystone Driller Company

Hedge & Mattheis Co.
31 Crescent St.
Butler Bin Company
Littleford Bros.

New England Implement Co.
The Roderick Lean Company

Waldo Bros. & Bond Co.
13 Federal St.
Sullivan Machinery Co.

Wickwire Spencer Steel Co.
80 Webster Street

Michigan

Alpena

Alpena Printing Studio
Buff & Buff Mfg. Co.

Bark River

Bark River Bridge & Culvert Co.
Armco Culvert Mfrs. Assn.
The Baker Mfg. Co.

Battle Creek

Tractor Sales & Service Co.
7 Park St.
The Cleveland Tractor Co.

Bay City

U. S. Bridge & Culvert Co.
Armco Culvert Mfrs. Assn.

Beaverton

L. D. White
Rawls Manufacturing Co.

Charlotte

Beach Manufacturing Co.
The Jos. Honhorst Co.

Detroit

W. H. Anderson Tool & Supply Co.
2178 Franklin St.
The Buffalo-Springfield Roller Co.
George Haiss Mfg. Co., Inc.
Littleford Bros.

Barber-Greene Company
6331-6351 Tireman Ave.

Barnes Wire Fence Co.
10371 Northlawn Ave.
Page Steel & Wire Co.

The Barrett Company
Zug Island Road (Delray P. O.)

Blaw-Knox Company
Lincoln Bldg.

Bucyrus-Erie Company
1136 Book Bldg.

Johns-Manville Co.
The Jos. Honhorst Co.

The Carey Company
6197 Hamilton Ave. at Baltimore
The Philip Carey Company

Celite Products Company
Book Bldg.

Cletrac Sales & Service
3491 Lincoln Ave.
The Cleveland Tractor Co.

Concrete Steel Fireproofing Co.
333 State St.
Hoosier Asphalt Company

Contractors Equip. Co.
5159-5169 Martin Ave.
The Baker Mfg. Co.
Bucyrus-Erie Company
Butler Bin Company
Domestic Engine & Pump Co.

M. A. Derr
6331 Tireman Ave.
Bay City Dredge Works

Detroit Trailer & Machine Co.
481 Beaufait Ave.
Hydraulic Hoist Mfg. Co.

Good Roads Supply Co.
6331 Tireman Ave.
Acme Road Machinery Co.
The Universal Crane Co.

Albert Grauer & Company
1408 Seventeenth St.
Asphalt Brick Company

Harnischfeger Corporation
452 Book Bldg.

The Heil Company
7341 Orleans St.

Hunter Machinery Co.
221 S. Waterman Ave.
Sauerman Bros., Inc.
Sullivan Machinery Co.

Ingersoll-Rand Co.
Marquette Bldg.

International Harvester Co. of America, Inc.

Jas. H. Phinney
420 U. S. Mortgage Bldg.
Williams Patent Crusher & Pulverizer Co.

Pulis Equipment Co.
5547 Tireman Ave.
Metal Forms Corporation
G. H. Williams Company

I. E. Rodgers Company
150 West Larned St.
Buff & Buff Mfg. Co.

Schuster Equipment Co.
10345 Northlawn Ave.
O. K. Clutch & Machinery Co.

Solvay Sales Corporation
7501 W. Jefferson Ave.
P. O. Box 557

George T. Wallace
1024 Dime Bank Bldg.
The Fate-Root-Heath Co.
Heltzel Steel Form & Iron Co.

Whitney Bros.
6464 Epworth Blvd.
Orton Crane & Shovel Co.

Wolfe Body Company
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

Escanaba

M. S. McNabb
The Cleveland Tractor Co.

Flint

Barnes Sales Company
500 N. Saginaw St.
Fruehauf Trailer Company

Wolfe Body Company
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

Frankfort

Mason Howard
The Cleveland Tractor Co.

Grand Rapids

W. H. Anderson Tool & Supply Co.
Littleford Bros.

Herbert L. Chapman
436½ Michigan Trust Bldg.
Williams Patent Crusher & Pulverizer Co.

Contractors Equipment Co.
18 Ellsworth Ave.
Domestic Engine & Pump Co.

Hunter Machinery Co.
530-32 Monroe Ave., North
Sauerman Bros., Inc.
Sullivan Machinery Co.

International Harvester Co. of America, Inc.

Kellogg-Burlingame Co.
67 Market Ave., N. W.
Butler Bin Company
G. H. Williams Company

F. D. Lake Company
16 Campau Ave., N. W.
George Haiss Mfg. Co., Inc.
Keystone Driller Company

Thomas G. McGurrin
250 Pearl St.
Fruehauf Trailer Company

Truman M. Smith Equip. Co.
154 Fitzhugh Ave.
Heltzel Steel Form & Iron Co.

Hartford

Warner & Olds
The Cleveland Tractor Co.

Highland Park

William Ford & Company
15841 Second Blvd.
Belle City Mfg. Co.

Iron Mountain

The Service & Supply Co.
107 East "A" Street
Heltzel Steel Form & Iron Co.

Jackson

Asa B. Hart
Care Dalton Hotel
Fruehauf Trailer Company

International Harvester Co. of America, Inc.

W. I. Thompson
102 North Bowen St.
Bay City Dredge Works

Lansing

Tri-State Tractor & Equip Co.
8th and Michigan Sts.
The Cleveland Tractor Co.
Ryan Manufacturing Corp.

Marquette

Lakeside Iron Works
Western Crucible Steel Casting Co.

G. S. Webb
5 Union National Bank Bldg.
George Haiss Mfg. Co., Inc.

Muskegon

Lake Shore Machinery Co.
1922 Peck St.
The Universal Crane Co.

Muskegon Heights

Schamber Brothers
1421 Peck St.
The Cleveland Tractor Co.

Paw Paw

Warner & Olds
100 Main St.
The Cleveland Tractor Co.

Saginaw

Engineering Sales & Service Co.
303 Second National Bank Bldg.
The Universal Crane Co.

International Harvester Co. of America, Inc.

Sault Ste. Marie

W. J. Armstrong Co.
The Galion Iron Works & Mfg. Co.

Skanee

Elmer Westrom
Rawls Manufacturing Co.

Minnnesota

Albert Lea

C. D. Edwards Mfg. Co., Inc.

Duluth

Borchert-Ingersoll, Inc.
303 Builders Exchange Bldg.
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.
Sullivan Machinery Co.
The Universal Crane Co.

C. D. Edwards Mfg. Co., Inc.
506 Sellwood Bldg.

Ingersoll-Rand Co.
Providence Bldg.

International Harvester Co. of America, Inc.

J. S. Ray Company
330 West First St.
Buff & Buff Mfg. Co.

Standard Salt & Cement Co.
237 South Lake Ave.
Acme Road Machinery Co.
Hercules Motors Corporation.

Sullivan Machinery Co.
Alworth Bldg.

Wm. H. Ziegler Co., Inc.
710 Providence Bldg.
Barber-Greene Company
Bucyrus-Erie Company
Butler Bin Company
The Fate-Root-Heath Co.
Littleford Bros.
G. H. Williams Company

Hollandale

Hollandale Hardware & Implement Co.
The Cleveland Tractor Co.

Hutchinson

D. H. & J. H. Chamberlain
The Galion Iron Works & Mfg. Co.

Mankato

International Harvester Co. of America, Inc.

Marshall

Maxson & Son
The Cleveland Tractor Co.

Minneapolis

The Barrett Company
1 Nineteenth Ave., S.

W. M. Bennett
206 West 27th St.
E. D. Etnyre & Co.

The Philip Carey Company
201 North Third St.

J. I. Case Threshing Mach. Co.

Crown City Iron Works Co.
13th Ave. and Tyler St., N. W.
Page Steel & Wire Co.

Wm. H. Hale & Co.
2529 University Ave., S. E.
The Cleveland Tractor Co.
Hercules Motors Corporation

Harnischfeger Corporation
330 Gateway Bank Bldg.

Hydraulic Hoist Co.
996 E. Hennepin Ave.

International Harvester Co. of America, Inc.

Lyle Culvert & Road Equip. Co.
Armco Culvert Mfrs. Assn.

Mine & Quarry Supply Co.
503 Kasota Bldg.
Keystone Driller Company

Minnesota Equipment Co.
419 South 8th St.
The Baker Mfg. Co.

Minnesota Refrigerating Co.
410-12 First St., North
Solvay Sales Corporation

W. S. Nott Company
2nd Ave North and 3rd St.
The Philip Carey Company

Thorman W. Rosholt Co.
928 S. Fourth St.
Metal Forms Corporation

Schurmeier-Whitney Co.
Lee Trailer & Body Co.

Telford K. Thompson
University and 13th Ave., S. E.
Fruehauf Trailer Company

Wm. H. Ziegler Co., Inc.
619 Washington Ave., S.
Barber-Greene Company
Bucyrus-Erie Company
The Buffalo-Springfield Boiler Co.
Butler Bin Company
The Fate-Root-Heath Co.
Littleford Bros.
Rawls Manufacturing Co.
G. H. Williams Company

St. Cloud

International Harvester Co. of America, Inc.

St. Paul

Austin-Western Road Machy. Co.
2328 Territorial Road
Western Wheeled Scraper Co.

Borchert-Ingersoll, Inc.
2360 University Ave.
Domestic Engine & Pump Co.
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.
Sullivan Machinery Co.
The Universal Crane Co.

Concrete Steel Company
958 Berrl Ave.
Hoosier Asphalt Company

Heil Northwestern Sales Co.
2651 University Ave.
Bay City Dredge Works
The Heil Company

Motor Power Equipment Co.
Belle City Mfg. Co.

Wm. H. Ziegler Co., Inc.
816 Pioneer Bldg.
Bucyrus-Erie Company

The Pittsburgh Plate Glass Co.

Thorman W. Rosholt Co.
Ersted Manufacturing Co.

Winona

International Harvester Co. of America, Inc.

Mississippi

Gulfport

M. Bulleman
3215 Fifteenth St.
Williams Patent Crusher & Pulverizer Co.

Hattiesburg

Munson Road Machinery Co.
The Cleveland Tractor Co.
Rawls Manufacturing Co.

Jackson

Anderson Sales & Distributors Co.
201 Millsaps Bldg.
Hercules Motors Corporation

Joe Barnes
Ryan Manufacturing Corp.

Meridian

H. G. Reed
4th St. and 23rd Ave.
Rawls Manufacturing Co.

Vicksburg

Morrissey-Easton Tractor Co.
Walnut and China Sts.
The Baker Mfg. Co.

West Jackson

Austin-Western Road Machy. Co.
Box 23
Western Wheeled Scraper Co.

Clifford Waterhouse
Box 337
Barber-Greene Company
Bay City Dredge Works

Missouri

Jefferson City

Geo. F. Smith Co.
1611 West Main St.
The Universal Crane Co.

Joplin

Ingersoll-Rand Drill Co.
P. O. Box 584

Joplin Supply Co.
Fourth and Wall Sts.
Sullivan Machinery Co.

Keystone Driller Company

Rogers Iron Works Company
The Fate-Root-Heath Co.

Kansas City

The Baird Road Machy. Co.
17th and Main Sts.
Rawls Manufacturing Co.

Barber-Greene Company
2045 Main St.

The Barrett Company
401 Railway Exchange Bldg.

Bublitz Machinery Co.
2139 Washington St.
Butler Bin Company
Metal Forms Corporation
G. H. Williams Company

Bunting Hardware & Machy. Co.
810 Walnut St.
Sullivan Machinery Co.

The Philip Carey Company
2008-2010 McGee St.

J. I. Case Threshing Mach. Co.

Celite Products Company
222 Lathtrop Bldg.

Concrete Steel Company
Finance Bldg.
Hoosier Asphalt Company

Jack Cooper & Bro.
214 East 19th St.
Ditwiler Manufacturing Co.

W. L. Eastlake
417 Continental Bldg.
Williams Patent Crusher & Pulverizer Co.

C. D. Edwards Mfg. Co., Inc.
423 West Fifth St.

English Brothers Machy. Co.
410 West Fifth St.
Hercules Motors Corporation

Funkhouser Equipment Co.
2425 Jefferson St.
Domestic Engine & Pump Co.
Ryan Manufacturing Corp.

The Galion Iron Works & Mfg. Co.
1205-07 Woodswether Ave.

Oswald Griner
313 East Tenth St.
Buff & Buff Mfg. Co.

Harnischfeger Corporation
601 New City Bank Bldg.

International Harvester Co. of America, Inc.

Kansas City Wire & Iron Works
1428 Oak St.
Page Steel & Wire Co.

National Steel Products Co.
1611 Crystal Ave.
Hydraulic Hoist Mfg. Co.

Newlin Motor Company
Ersted Manufacturing Co.

Victor L. Phillips Co.
16th and Baltimore Sts.
Bucyrus-Erie Company
The Buffalo-Springfield Roller Co.
The Fate-Rooth-Heath Co.
George Haiss Mfg. Co., Inc.
Heltzel Steel Form & Iron Co.
Littleford Bros.
The Universal Crane Co.
Western Wheeled Scraper Co.

The Pittsburgh Plate Glass Co.

Universal Equipment Co.
1201 Winchester Ave.
Belle City Mfg. Co.

Moberly

Corrugated Culvert Company
Armco Culvert Mfrs. Assn.

St. Joseph

International Harvester Co. of America, Inc.

St. Louis

O. B. Avery Company
1325 Macklind Ave.
Butler Bin Company
Domestic Engine & Pump Co.
G. H. Williams Company

Bailey Auto Body Co.
2649-51 Chouteau Ave.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

The Barrett Company
1 Convent St.

The Philip Carey Company
4485-4487 Duncan Ave.

J. I. Case Threshing Mach. Co.

Celite Products Company
Railway Exchange Bldg.

Concrete Steel Company
802 Chestnut St.
Hoosier Asphalt Company

Fickeissen-Finney Equip. Co.
Ryan Manufacturing Corp.

Fink Instrument Co.
804 Fine St.
Buff & Buff Mfg. Co.

L. V. Fraley & Son
513 Buder Bldg.
Barber-Greene Company
The Fate-Root-Heath Co.
Sauerman Bros., Inc.

Harnischfeger Corporation
524 Buder Bldg.

Herman Body Company
4420 Clayton Ave.
Hydraulic Hoist Mfg. Co.

The Highway Materials Co.
Title Guaranty Bldg.
The Grasselli Chemical Co.

Ingersoll-Rand Drill Co.
314 North Broadway

International Harvester Co. of America, Inc.

C. J. Kloske
725 Buder Bldg.
Fruehauf Trailer Company

Kranz Automotive Body Co.
3032 Gravois Ave.
The Heil Company

Lincoln Equip. & Materials Co.
Keystone Driller Company

L. R. Payton
2041 Railway Exchange Bldg.
G. H. Williams Company

The Pittsburgh Plate Glass Co.

C. F. Rabbeitt
Railway Exchange Bldg.
Littleford Bros.

Henry K. Robinson
Federal Comm. Trust Bldg.
Bay City Dredge Works

Sears & Piou
1001 North 6th St.
Page Steel & Wire Co.

The Geo. F. Smith Co.
Franklin and Channing Aves.
Domestic Engine & Pump Co.
The Universal Crane Co.

Solvay Sales Corporation
704 Laclede Gas Bldg.

Sullivan Machinery Co.
2006 Railway Exchange Bldg.

W. D. Tully Equip. Co.
2339 Pine St.
George Haiss Mfg. Co., Inc.
Heltzel Steel Form & Iron Co.
Orton Crane & Shovel Co.

F. Weber Company
Buff & Buff Mfg. Co.

Western Wheeled Scraper Co.
2918 South Broadway

The Walter A. Zelnicker Supply Co.
511 Locust St.
O. K. Clutch & Machinery Co.

Springfield

International Harvester Co. of America, Inc.

Montana

Billings

iAustin-Western Road Machy. Co.
Western Wheeled Scraper Co.

E. L. Blake Company
P. O. Box 1618
O. K. Clutch & Machinery Co.

J. I. Case Threshing Mach. Co.

Goan Motor Company
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

International Harvester Co. of America, Inc.

Northwest Equipment Co.
Box 1084
Barber-Greene Company
Western Crucible Steel Casting Co.

Butte

Hall-Perry Machinery Co.
802 East Iron St.
Butler Bin Company
The Cleveland Tractor Co.
Fruehauf Trailer Company
The Galion Iron Works & Mfg. Co.
George Haiss Mfg. Co., Inc.
The Heil Company

Ingersoll-Rand Co.
303 Lewisohn Bldg.

Montana Auto & Garage Co.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

Northwest Equip. Co., Inc.
14 West Granite St.
Barber-Greene Company
Bucyrus-Erie Company
The Buffalo-Springfield Roller Co.

Sullivan Machinery Co.
48 East Broadway

Great Falls

Northwest Equipment Co.
Box 1112
Barber-Greene Company

Helena

International Harvester Co. of America, Inc.

Nebraska

Hastings

The Nebraska Road Equip. Co.
115 South St. Joe Ave.
The Galion Iron Works & Mfg. Co.

Lincoln

J. I. Case Threshing Mach. Co.

Gate City Iron Works
1118 Federal Trust Bldg.
Page Steel & Wire Co.

International Harvester Co. of America, Inc.

Omaha

American Machinery & Supply Co.
1113 Howard St.
The Buffalo-Springfield Roller Co.
Domestic Engine & Pump Co.
Heltzel Steel Form & Iron Co.
Hercules Motors Corporation
Sullivan Machinery Co.
The Universal Crane Co.

Badger Body Mfg. Co.
Ditwiler Manufacturing Co.

Concrete Steel Company
310 Finance Bldg.
Hoosier Asphalt Company

Contractors Supply Co.
1612 California St.
Western Wheeled Scraper Co.

C. D. Edwards Mfg. Co., Inc.
13th and Willis Ave.

Fuchs Equipment Co.
1003 Farnum St.
The Good Roads Machinery Co.
Harnischfeger Corporation
Littleford Bros.

Gate City Iron Works
11th and Seward Sts.
Page Steel & Wire Co.

Holland Lumber Company
6th and Douglass Sts. (P. O. Box 1197)
The Philip Carey Company

Industrial Machinery & Supply Co.
1101 Jackson St.
The Cleveland Tractor Co.
The Galion Iron Works & Mfg. Co.

International Harvester Co. of America, Inc.

Interstate Machy. & Supply Co.
1006-10 Douglas St.
Acme Road Machinery Co.
Bucyrus-Erie Company
Butler Bin Company
The Fate-Root-Heath Co.
George Haiss Mfg. Co., Inc.
G. H. Williams Company

Larrabee Equipment Co.
Ryan Manufacturing Corp.

Nebraska Auto & Truck Mfg. Co.
30th St. and Sprague Ave.
Hydraulic Hoist Mfg. Co.

The T. G. Northwall Co.
The Roderick Lean Company

The Pittsburgh Plate Glass Co.

Wahoo

Nebraska Culvert & Mfg. Co.
Armco Culvert Mfrs. Assn.

Nevada

Reno

Durham Chevrolet Co.
Ditwiler Manufacturing Co.

New Hampshire

Manchester

C. W. Watson & Sons, Inc.
68 Carroll St.

Nashua

New England Metal Culvert Co.
Armco Culvert Mfrs. Assn.

New Jersey

Allendale

Allendale Equipment Co.
The Roderick Lean Company

Camden

International Harvester Co. of America, Inc.

Elizabeth

International Harvester Co. of America, Inc.

Irvington

The Cope Company
1084 Clinton St.
The Heil Company

Jersey City

Contractors Equipment Co.
Jersey Journal Bldg.
Sullivan Machinery Co.
G. H. Williams Company

International Harvester Co. of America, Inc.

Moorestown

C. A. Lippincott & Bro.
Third and Union Sts.
The Cleveland Tractor Co.

Newark

Ingersoll-Rand Co.
236 High St.

International Harvester Co. of America, Inc.

Johnson & Dealaman, Inc.
60 Marshall St.
Harnischfeger Corporation

E. B. Kelley Co., Inc.
326 Frelinghuysen Ave.
Heltzel Steel Form & Iron Co.

F. J. Lewis Mfg. Company
200 to 300 Daremus Ave.

C. H. Loomis & Sons Co.
304 Jelliff Ave.
Domestic Engine & Pump Co.

C. A. Prescott & Co.
14 Van Buren St.
The Cleveland Tractor Co.

Stutz-Sickles Co.
121-123 Lafayette St.
Rawls Manufacturing Co.

Roselle

Eugene P. Reading
Bay City Dredge Works

Trenton

The Pittsburgh Plate Glass Co.

Verona

J. H. Rainsbury
26 Grove Ave.
E. D. Etnyre & Co.

New Mexico

Albuquerque

J. Korber & Company
Western Wheeled Scraper Co.

New Mexico Road Machinery Co.
P. O. Box 665
Barber-Greene Company
The Cleveland Tractor Co.
Heltzel Steel Form & Iron Co.
Sauerman Bros., Inc.

Sorenson Brick & Material Co.
North First St. and Marble Ave.
The Philip Carey Company

Winter-Weiss Co.
Ditwiler Manufacturing Co.

Roswell

New Mexico Road Equip. Co.
124 East Fourth St.
The Heil Company

New York

Albany

Austin-Western Road Machy. Co.
350 Broadway
Western Wheeled Scraper Co.

The Philip Carey Company
46 Spencer St.

Good Roads Machinery Co.
36 State St.
George Haiss Mfg. Co., Inc.

Hercules Sales Co. of N. Y.
Tivoli St.
Ditwiler Manufacturing Co.

International Harvester Co. of America, Inc.

E. B. Kelley Co., Inc.
Broadway
Heltzel Steel Form & Iron Co.

L. R. Mack, Inc.
Washington Ave. and No. Blvd.
Hydraulic Hoist Mfg. Co.

The Pittsburgh Plate Glass Co.

Sager-Spuck Supply Co., Inc.
364 Broadway
Domestic Engine & Pump Co.
Sullivan Machinery Co.

R. B. Wing & Son Corp.
384 Broadway
Harnischfeger Corporation
G. H. Williams Company

Auburn

International Harvester Co. of America, Inc.

Binghamton

International Harvester Co. of America, Inc.

Titchener Iron Works, Inc.
23 Griswold St.
Page Steel & Wire Co.

Wilcox Bros.
Heltzel Steel Form & Iron Co.

W. C. Williams
29 Dennison St.
O. K. Clutch & Machinery Co.

Bronx

International Harvester Co. of America, Inc.

Brooklyn

International Harvester Co. of America, Inc.

Phillips & West
1773 Sixtieth St.
Bay City Dredge Works

Jos. G. Pollard Co.
The Jos. Honhorst Co.

Buffalo

H. W. Benkart
Lafayette Sq. Bldg.
Butler Bin Company
Harnischfeger Corporation

Blaw-Knox Company
Genessee Bldg.

Bucyrus-Erie Company
724 Genesee Bldg.

Buffalo Fence Construction Co.
1166 Elk St.
Page Steel & Wire Co.

The Carey Company, Inc.
1172-1178 Niagara St.
The Philip Carey Company

Celite Products Company
1018 Genesee Bldg.

Jos. K. Fiorello
189 Van Rensselaer St.
Sullivan Machinery Company

S. A. Gilliard
524 White Bldg.
Barber-Greene Company

Good Roads Machinery Co.
733 Ellicott Square Bldg.
George Haiss Mfg. Co., Inc.

Hercules Sales Co.
Main and Amherst Sts.
Ditwiler Manufacturing Co.

Ingersoll-Rand Co.
Ellicott Square

International Harvester Co. of America, Inc.

E. B. Kelley Co., Inc.
313 Niagara St.
Heltzel Steel Form & Iron Co.

W. B. May, Inc.
Belle City Mfg. Co.

B. J. Moore & Co., Inc.
2460 Main St.
The Roderick Lean Company

The Pittsburgh Plate Glass Co.

L. P. Smith
35 Wingate Ave.
Wickwire Spencer Steel Co.

Truck Equipment Co.
1791 Fillmore St.
Fruehauf Trailer Company
Hydraulic Hoist Mfg. Co.

Watkins Commercial Body Corp.
666 Genesee St.
The Heil Company

J. H. Welch
21 Terrace
O. K. Clutch & Machinery Co.

Seward S. Wells Co.
504 Brisbane Bldg.
Bay City Dredge Works

H. Wetherald
11 Taft Place
Domestic Engine & Pump Co.
George Haiss Mfg. Co., Inc.

The Wheeler-Murray Co.
329-331 Ellicott St.
Littlefold Bros.

Geo. W. Whitehead Co.
61 The Terrace
Acme Road Machinery Co.
Metal Forms Corporation
Sullivan Machinery Co.
G. H. Williams Company

Wickwire Spencer Steel Co.
River Road

Canandaigua

Z. T. Darrow & Son
Keystone Driller Company
Ryan Manufacturing Corp.

East Aurora

A. O. Zink & Sons
The Cleveland Tractor Co.

Elmira

J. I. Bingham
451 W. Gray St.
O. K. Clutch & Machinery Co.

Highway Products & Mfg. Co., Inc.
Armco Culvert Mfrs. Assn.

International Harvester Co. of America, Inc.

Ft. Edward

Newton & Hill
Page Steel & Wire Co.

Fredonia

R. L. Harris
69 Hamlet St.
The Cleveland Tractor Co.

Herkimer

Howard E. Seymour
R. F. D. No. 1
The Cleveland Tractor Co.

Horseheads

E. Van Name
The Burch Corporation

Interlaken

Lester Mosher
Bay City Dredge Works

Kingston

Universal Road Machinery Co.
The Heil Company

Livingston

John R. Tinklepaugh
The Cleveland Tractor Co.

Hempstead, L. I.

Craig Haysman
Lawson Street
Wickwire Spencer Steel Co.

Long Island City

The Heil Company
Rawson St. and Queens Blvd.

Interboro Hoist & Body Corp.
Borden Ave. and Van St.
Hydraulic Hoist Mfg. Co.

International Harvester Co. of America, Inc.

Newark

Arcadia Truck Body Corp.
Hydraulic Hoist Mfg. Co.

New Hyde Park

Geo. Malvese & Company
Jericho Turnpike
The Cleveland Tractor Co.
Rawls Manufacturing Co.

New York City

Acme Road Machinery Co.
120 Liberty St.

Allied Machinery Co. of America
90 Wall St.
Barber-Greene Company

Barber-Greene Company
141 Centre St.

The Barrett Company
40 Rector St.

Blaw-Knox Company
Canadian Pacific Bldg.

Brook Iron Works, Inc.
99 Church St.
Page Steel & Wire Co.

Bucyrus-Erie Company
50 Church St.

Bucyrus-Erie Company
117 Liberty St.

The Philip Carey Company
Rm. 1104—501 Fifth Ave.

The Philip Carey Co. (Domestic Dept.)
Rm. 1105—501 Fifth Ave.

The Philip Carey Company (Exp. Dept.)
Rm 518—90 West St.

Celite Products Company
11 Broadway

Concrete Steel Company
42 Broadway
Hoosier Asphalt Company

F. H. Conklin and W. G. Harrington, Inc. (Export)
50 Church St.
The Galion Iron Works & Mfg. Co.

H. M. Cooper
Rm. 404—152 W. 42nd St.
Sauerman Bros., Inc.

The Cumming Company
Hudson Terminal—50 Church St.
Littleford Bros.

James N. Davies
The Burch Corporation

John A. Dewey
15 Park Row
The Baker Mfg. Co.

John Dunn Sons Co. (Export)
44 Whitehall St.
Keystone Driller Company

Good Roads Machinery Co.
50 Church St.
The Galion Iron Works & Mfg. Co.
George Haiss Mfg. Co., Inc.

Frank E. Hall
152 West 42nd St.
Heltzel Steel Form & Iron Co.

Harnischfeger Corporation
50 Church St.

H. E. Hein (Foreign Rep.)
152 West 42nd St.
Heltzel Steel Form & Iron Co.

H. S. Henry (Export)
116 Broad St.
Keystone Driller Company

The Hubbard-Floyd Co., Inc.
452 Lexington Ave.
G. H. Williams Company

H. J. Hush, Inc.
36-40 West 60th St.
Domestic Engine & Pump Co.

Norman Huston
50 Church St.
Alan Wood Iron & Steel Co.

Ingersoll-Rand Co.
11 Broadway

Interboro Hoist & Body Corp.
Borden Ave. & Van Dam St. (L. I. City, N. Y.)

International Harvester Co. of America, Inc.

E. B. Kelley Co., Inc.
130 West 42nd St.
Heltzel Steel Form & Iron Co.

Keystone Driller Company
Rm. 1715—170 Broadway

Kongo Shokwai
60 Beaver St.
George Haiss Mfg. Co., Inc.

Francis H. Love Co., Inc.
Grand Central Palace
Lexington Ave. & E. 46th St.
Rawls Manufacturing Co.

Mead-Morrison Mfg. Co.
149 Broadway

Milliken Bros.-Blaw Knox Corp.
Exp. Div. 342 Madison Ave.
Blaw Knox Company

Neafie & Fanning
50 Church St.
The Fate-Root-Heath Co.

B. Nicoll & Company
292 Madison Ave.
Orton Crane & Shovel Co.

Henry W. Peabody Co. (Export)
17 State St.
Orton Crane & Shovel Co.

H. O. Penn Mach. Co.
18 East 41st St.
Butler Bin Company
O. K. Clutch & Machinery Co.

The Pittsburgh Plate Glass Co.

Eugene P. Reading
302 Broadway
Bay City Dredge Works

Richards & Hirschfeld
50 Church St.
Hercules Motors Corporation

O. J. Rittenhouse
Tribune Bldg.—154 Nassau St.
Metal Forms Corporation

Solvay Sales Corporation
40 Rector St.

Sullivan Machinery Co.
30 Church St.

W. H. Van Vleck
50 Church St.
Alan Wood Iron & Steel Co.

Western Wheeled Scraper Co.
50 Church St.

Wickwire Spencer Steel Co.
41 East 42nd Street

G. H. Williams Company
Rm. 502-E—30 Church St.

Williams Patent Crusher & Pulverizer Co.
15 Park Row

Ogdensburg

International Harvester Co. of America, Inc.

Pen Yan

Wm. Stoutenburg
The Burch Corporation
The Galion Iron Works & Mfg. Co.

Plattsburg

Chapman Motor Company
Ditwiler Manufacturing Co.

Pleasantville

C. V. Pierce
The Cleveland Tractor Co.

Rochester

The Barrett Company
Brighton Station

Bashford-McCord Corp.
1346 University Ave.
The Baker Mfg. Co.

Haverstick & Company
Ford and Spring Sts.
Domestic Engine & Pump Co.

C. H. Ineson
116 Exchange Place Bldg.
Sullivan Machinery Co.

International Harvester Co. of America, Inc.

Keystone Builders Supply Co.
85 Palm St.
Heltzel Steel Form & Iron Co.
O. K. Clutch & Machinery Co.

F. E. Madigan
460 Maplewood Ave.
George Haiss Mfg. Co., Inc.

H. H. Sullivan
67 South Ave.
Buff & Buff Mfg. Co.

Seward S. Wells Co.
Bay City Dredge Works

H. Wetherald
460 Maplewood Ave.
George Haiss Mfg. Co., Inc.

The Wheeler-Murray Co.
Builders Exchange
Littleford Bros.

George W. Whitehead Co.
1135 Bay St.
G. H. Williams Company

Rockville Centre

E. B. Kelley Co., Inc.
169 Observer St.
Heltzel Steel Form & Iron Co.

Salem

Acme Road Machinery Co.

Schenectady

The Fireproof Products Co.
207 State St.
Rawls Manufacturing Co.

Syracuse

The Barrett Company
P. O. Box 46—State Fair Blvd.

Brewster & Williams, Inc.
613 Dillaye Bldg.
George Haiss Mfg. Co., Inc.
Littleford Bros.
Sullivan Machinery Co.

Clarence H. Buell
404 S. Clinton St.
Metal Forms Corporation

The Philip Carey Company
111 Crouse Ave.

J. I. Case Threshing Mach. Co.

Concrete Steel Company
201 East Water St.
Hoosier Asphalt Company

International Harvester Co. of America, Inc.

Miller Equipment Co.
127 Solar St.
Domestic Engine & Pump Co.

Solvay Sales Corporation
P. O. Box 1 and 2

Syracuse Supply Co.
O. K. Clutch & Machinery Co.

Truck Equipment Co.
318-342 S. West St.
Fruehauf Trailer Company
Hydraulic Hoist & Body Co.

Tarrytown

Hercules Sales Co. of N. Y.
Josephine St.
Ditwiler Manufacturing Co.

Troy

Fred K. Blanchard, Inc.
422 River St.
Page Steel & Wire Co.

E. B. Kelley Co., Inc.
124 Ferry St.
Heltzel Steel Form & Iron Co.

Utica

Barber-Greene Company
216 Union Station

J. Shuman Hower
106 Foster Bldg.
The Universal Crane Co.
G. H. Williams Company

International Harvester Co. of America, Inc.

Watertown

Thomas H. Bradley
122 Arsenal St.
Page Steel & Wire Co.

International Harvester Co. of America, Inc.

Webster

Sutherland & Smith
The Cleveland Tractor Co.

North Carolina

Asheville

G. C. Varner
The Good Roads Machinery Co.

Charlotte

American Hardware & Supply Co.
Equipment Division
Acme Road Machinery Co.
Fruehauf Trailer Company

J. F. Campbell
210 Builders Bldg.
O. K. Clutch & Machinery Co.

The Philip Carey Company
439-441 S. Cedar St. (P. O. Box 203)

The Charlotte Supply Co.
Mint & First Sts. (P. O. Box 440)
The Philip Carey Company

General Equipment Co.
1411 S. Mint St.
Page Steel & Wire Co.

Harnischfeger Corporation
1101 Johnston Bldg.

International Harvester Co. of America, Inc.

Chas. A. Torrence
214 Latta Arcade
Buff & Buff Mfg. Co.

Union Storage & Warehouse Co.
Ditwiler Manufacturing Co.

Greensboro

E. F. Craven Co.
"The Road Machinery Men"
The Baker Mfg. Co.
Bucyrus-Erie Company
The Buffalo-Springfield Roller Company
Domestic Engine & Pump Co.
George Haiss Mfg. Co., Inc.
Littleford Bros.
Metal Forms Corporation
Rawls Manufacturing Co.
The Universal Crane Co.
Western Wheeled Scraper Co.
G. H. Williams Company

The Galion Iron Works & Mfg. Co.
Box 930

J. D. Wilkins
W. Lee St. at Glenwood Ave.
Sauerman Bros., Inc.

Raleigh

Dillon Supply Company
Domestic Engine & Pump Co.

Motor & Equipment Co.
215 East Davie St.
Sullivan Machinery Co.

Salisbury

Carolina Tractor & Equip. Co.
Sullivan Machinery Co.

Winston-Salem

International Harvester Co. of America, Inc.

The Pittsburgh Plate Glass Co.

North Dakota

Bismark

International Harvester Co. of America, Inc.

Dickinson

Hauser & Hauser, Inc.
The Cleveland Tractor Co.

Fargo

J. I. Case Threshing Mach. Co.

C. D. Edwards Mfg. Co., Inc.
North Dakota Metal Culvert Co.

International Harvester Co. of America, Inc.

Lewis Motor Company
Harnischfeger Corporation

Grand Forks

International Harvester Co. of America, Inc.

Minot

International Harvester Co. of America, Inc.

Tolno

George Beckman
The Cleveland Tractor Co.

Wahpeton

Northwestern Sheet & Iron Works
Armco Culvert Mfrs. Assn.
Ryan Manufacturing Corp.

Ohio

Akron

Foltz Body Company
7882 Summit St.
Ditwiler Manufacturing Co.

International Harvester Co. of America, Inc.

The Pittsburgh Plate Glass Co.

Ashville

J. S. Roof
Page Steel & Wire Co.

Canton

J. C. Neely & Co.
201 Goldberg Bldg.
Domestic Engine & Pump Co.
Littleford Bros.

Cincinnati

Barber-Greene Company
431 Temple Bar Bldg.

The Barrett Company
517 Carr St.

The Breese Bros. Co. (Roofing Dept.)
2347 Reading Rd.
The Philip Carey Company

Lawrence Bruder Co.
211 W. 2nd St.
Hydraulic Hoist Mfg. Co.

The Philip Carey Co. (Cincinnati Branch)
Lockland, Cincinnati

The Philip Carey Co. (Home Office)
Lockland, Cincinnati

Celite Products Company
705 Neave Bldg.

Geo. B. Curd Equipment Co.
609 Reading Road
Butler Bin Company
George Haiss Mfg. Co., Inc.

The Davis & Siehl Co.
4032 Hamilton Ave.
Page Steel & Wire Co.

George Ennis
802 Mercantile Library Bldg.
O. K. Clutch & Machinery Co.

H. G. Hehman
910 Mercantile Library Bldg.
Fruehauf Trailer Company

International Harvester Co. of America, Inc.

Wm. T. Johnston Co.
Third and Vine Sts.
Western Wheeled Scraper Co.

Kelly Spring Co.
2246 Spring Grove Ave.
Bay City Dredge Works
Heltzel Steel Form & Iron Co.

Littleford Bros.
443-457 E. Pearl St.

The Pittsburgh Plate Glass Co.

L. M. Prince Company
108 W. Fourth St.
Buff & Buff Mfg. Co

Prues Equipment Co.
2118 Spring Grove Ave.
Harnischfeger Corporation

Queen City Supply Co.
Cor Pearl and Elm Sts.
Domestic Engine & Pump Co.
Hercules Motors Corporation
Lee Trailer & Body Co.
Metal Forms Corporation
Sauerman Bros., Inc.
G. H. Williams Company

Solvay Sales Corporation
612 Gwynne Bldg.

Ferd. Wagner Company
113 E. Fifth St.
Buff & Buff Mfg. Co.

D. R. Van Atta Seed Co.
3132 Spring Grove Ave.
The Cleveland Tractor Co.

Cleveland

Barber-Greene Company
1637 Superior Ave.

The Barrett Company
1730 Walworth Ave.

The Betz-Pierce Company
2230 E. 9th St.
Page Steel & Wire Co.

Blaw-Knox Company
616 Union Bldg.

J. G. Bricker Co.
470 Hanna Bldg.
Heltzel Steel Form & Iron Co.

Cadwell Tractor Co.
1510 University Rd.
The Baker Mfg. Co.

The Carey Company
5906-16 Euclid Ave.
The Philip Carey Company

Celite Products Company
Bulkley Bldg.

The Cletrac Ohio Sales Co.
19300 Euclid Ave.
The Cleveland Tractor Co.

Concrete Steel Company
1740 E. 12th St.
Hoosier Asphalt Company

Day & Maddock
W. 82nd St. Near Dennison
George Haiss Mfg. Co., Inc.
Sullivan Machinery Co.

Dravo Equipment Co.
4800 Prospect Ave.
G. H. Williams Company

B. K. Elliott Company
733 Prospect Ave.
Buff & Buff Mfg. Co.

Harnischfeger Corporation
340 Rockefeller Bldg.

Ingersoll-Rand Co.
Williamson Bldg.

International Harvester Co. of America, Inc.

H. S. Moore
1373 E. 18th St.
Fruehauf Trailer Company

The Ohio Truck Body & Wagon Company
3291 E. 65th St.
Hydraulic Hoist Mfg. Co.

The W. M. Pattison Supply Co.
777 Rockwell Ave.
Domestic Engine & Pump Co.
Ersted Manufacturing Co.
Littleford Bros.
Western Wheeled Scraper Co.

Peden Equipment Co.
10230 Berea Rd.
Butler Bin Company
O. K. Clutch & Machinery Co.

E. F. Pegg Equip. Co.
130 Engineers Bldg.
Bay City Dredge Works

The Pittsburgh Plate Glass Co.

The Prues Equipment Co., Inc.
308 Hazen Bldg.
The Baker Mfg. Co.

R. G. Schultz
Care Gus. Schaefer Wagon Co.
4180 Lorain Ave.
The Heil Company

Solvay Sales Corporation
1846 Scranton Rd.

G. G. Stein
1008 Fidelity Mortgage Bldg.
The Fate-Root-Heath Co.

Sullivan Machinery Co.
1506 Rockefeller Bldg.

R. J. Thomas
7629 Broadway
Orton Crane & Shovel Co.

Thorne-Hawk Body Co.
2102 East 22nd St.
Ditwiler Manufacturing Co.

F. A. Weaver
6007 Euclid Ave.
Asphalt Brick Company

Wickwire Spencer Steel Co.
714 Guarantee Title Bldg.

G. H. Williams Company
12228 Clifton Blvd.

Columbus

Austin-Western Road Machy. Co.
303 Stoneman Bldg.
Western Wheeled Scraper Co.

The Barrett Company
428 Neilson St.

The Philip Carey Company
32 East Swan St.

F. A. Carvin Company
580 Hamlet St.
Hydraulic Hoist Mfg. Co.

J. I. Case Threshing Mach. Co.

Consolidate Equipment Co.
157 W. Main St.
Keystone Driller Company
Sullivan Machinery Co.

Hercules Body Sales Co.
36 East Swan St.
Ditwiler Manufacturing Co.

International Harvester Co. of America, Inc.

John McNeilly
335 S. High St.
Hercules Motors Corporation

Clarence E. Mahoney
890 N. Fourth St.
Fruehauf Trailer Company

Milburn Machinery Co.
141 N. Front St.
Domestic Engine & Pump Co.
George Haiss Mfg. Co., Inc.
Harnischfeger Corporation
Metal Forms Corporation

The Pittsburgh Plate Glass Co.

F. O. Schoedinger
The Jos. Honhorst Co.

G. L. Stith Company
305 Franklin Bldg.
High and Main Sts.
Butler Bin Company
Heltzel Steel Form & Iron Co.
Littleford Bros.

Taylor Tractor Co.
77 E. Naghten St.
The Baker Mfg. Co.
G. H. Williams Company

The W. W. Williams Co.
987 W. Goodale St.
The Cleveland Tractor Co.
Ryan Manufacturing Corp.

Crestline

The Burch Corporation
Acme Road Machinery Co.

Dayton

The Philip Carey Company
Weakley St. and B. & O. Ry.

Geo. B. Curd Equipment Co.
901 Five Oaks Ave.
Butler Bin Company

Flack Equipment Company
O. K. Clutch & Machinery Co.

International Harvester Co. of America, Inc.

Queen City Supply Co.
507 S. Jefferson St.
Domestic Engine & Pump Co.
Sauerman Bros., Inc.
G. H. Williams Company

Jackson

E. O. Connery
222 Court St.
Rawls Manufacturing Co.

Middletown

Ingot Iron Railway Products Co.
Armco Culvert Mfrs. Assn.

Ohio Corrugated Culvert Co.
Armco Culvert Mfrs. Assn.

New Bremen

Auglaize Hoist & Body Co.
Hydraulic Hoist Mfg. Co.

Norwood

Hercules-Norwood Body Sales Co.
Cor. Smith Rd. and Elm Ave.
Ditwiler Manufacturing Co.

The Pittsburgh Plate Glass Co.

Springfield

International Harvester Co. of America, Inc.

T. J. Lane Equipment Co.
1024 West Main St.
Bay City Dredge Works

Thornville

F. J. Lewis Mfg. Company
Care Geo. W. Shelby

Toledo

The Barrett Company
2762 Front St.

The Carey Company
219 Cherry St.
The Philip Carey Company

F. A. Carvin Company
214 Locust St.
Hydraulic Hoist Mfg. Co.

Contractors Machinery Co.
367 South Erie St.
Heltzel Steel Form & Iron Co.

Flack Equipment Co.
1005 Summit St.
Domestic Engine & Pump Co.
O. K. Clutch & Machinery Co.

International Harvester Co. of America, Inc.

W. H. Kuhlman Co.
340 Water St.
Butler Bin Company
Metal Forms Corporation
Sullivan Machinery Co.
G. H. Williams Company

J. R. McCormick
320 Terminal Bldg.
Fruehauf Trailer Company

A. F. Miller Tractor Co.
S. Erie St.
The Baker Mfg. Co.
E. D. Etnyre & Co.

W. A. Miller
c-o Madison Hotel
Metal Forms Corporation

National Supply Co.
P. O. Box 899
George Haiss Mfg. Co., Inc.

Shop of Siebert
614 Southard Ave.
The Heil Company

Thorne-Hawk Body Co.
1510 Elm St.
Ditwiler Manufacturing Co.

Toledo Sales & Engineering Co.
16 North St. Clair St.
Bay City Dredge Works

Washington Court House

W. W. Wilson & Son
Page Steel & Wire Co.

Youngstown

The Barrett Company
12 Poland Ave.

Frank Bowers
Park Theatre Bldg.
Heltzel Steel Form & Iron Co.

H. R. Hooper Company
2105 Market St.
Belle City Mfg. Co.

The Pittsburgh Plate Glass Co.

Stambaugh-Thompson Co.
West Federal St.
Domestic Engine & Pump Co.

J. Walker Wilson
1009 Mahoning Bank Bldg.
Keystone Driller Company
Sullivan Machinery Co.

Zanesville

The F. Wilking & Sons Co.
36 North Fifth St.
Page Steel & Wire Co.

Oklahoma

Blackwell

Western Supply Company
Hercules Motors Corporation

Covington

Western Supply Company
Hercules Motors Corporation

Cromwell

Western Supply Company
Hercules Motors Corporation

Enid

C. D. Edwards Mfg. Co., Inc.

Bert Smith
P. O. Box 43
The Cleveland Tractor Co.
Rawls Manufacturing Co.

Guthrie

Clarence L. Boyd Co.
E. D. Etnyre & Co.

Muskogee

Muskogee Iron Works, Inc.
The Good Roads Machinery Co.

Sullivan Machinery Co.
428 N. Second St.

Oklahoma City

American Tank Company
Hydraulic Hoist Mfg. Co.

Austin-Western Road Machy. Co.
140 East Washington
Western Wheeled Scraper Co.

Baird Road Machinery Co.
Lawrence Hotel
The Cleveland Tractor Co.

The Boardman Company
Armco Culvert Mfrs. Assn.
The Baker Mfg. Co.
Western Wheeled Scraper Co.

J. I. Case Threshing Mach. Co.

Funkhauser Equipment Co.
126 E. Grand Ave.
Domestic Engine & Pump Co.
Ryan Manufacturing Corp.

Herd Equipment Company
543 West Pine St.
The Galion Iron Works & Mfg. Co.

International Harvester Co. of America, Inc.

H. N. Knight Supply Co.
901 W. Grand Ave.
Ditwiler Manufacturing Co.

Victor L. Phillips Co.
600 W. Main St.
Bucyrus-Erie Company
The Buffalo-Springfield Roller Company
The Fate-Root-Heath Co.
George Haiss Mfg. Co., Inc.
Heltzel Steel Form & Iron Co.
Littleford Bros.
The Universal Crane Co.

R. W. Ragsdale
P. O. Box 1373
O. K. Clutch & Machinery Co.

Ryan Equipment Co.
Lee Trailer & Body Co.

Wylie Brothers
208 E. Grand Ave.
Acme Road Machinery Co.
Barber-Greene Company
Ersted Manufacturing Co.
Metal Forms Corporation
Sullivan Machinery Co.
G. H. Williams Company

C. J. Wolaver
Grain Exchange Bldg.
Williams Patent Crusher & Pulverizer Co.

Tulsa

Circle Corporation, Inc.
508 Central Nat'l Bank Bldg.
Bay City Dredge Works
O. K. Clutch & Machinery Co.

Federal Storage Company
Ditwiler Manufacturing Co.

H. N. Knight Supply Co.
Ditwiler Manufacturing Co.

Leland Truck Equipment Co.
30 North Owasso St.
Barber-Greene Company
Hydraulic Hoist Mfg. Co.

Victor L. Phillips Co.
541 S. Troost St.
Bucyrus-Erie Company
The Buffalo-Springfield Roller Company
Heltzel Steel Form & Iron Co.
Littleford Bros.
The Universal Crane Co.

Triangle B. P. & Supply Co.
Hotel Tulsa Bldg.
Buff & Buff Mfg. Co.

Tulsa Eng. & Supply Co.
116 W. Third St.
Buff & Buff Mfg. Co.

Tulsa Fence and Post Co.
213 S. Madison Ave.
Page Steel & Wire Co.

Western Supply Company
Hercules Motors Corporation

Williamson Motors, Inc.
418 N. Main St.
Fruehauf Trailer Company

Oregon

Baker

Basche-Sage Hardware Co.
Sullivan Machinery Co.

Medford

Gaddis & Dixon
134 N. Riverside Ave.
Page Steel & Wire Co.

Portland

Austin-Western Road Machinery Company
354 Belmont St.
Western Wheeled Scraper Co.

Balfour Guthrie Co.
353 Oak St.
Solvay Sales Corporation

Pure Iron Culvert & Mfg. Co.
Armco Culvert Mfrs. Assn.

Celite Products Company
49 First St.

Clyde Equipment Co.
17th and Thurman Sts.
Acme Road Machinery Co.
Bucyrus-Erie Company
George Haiss Mfg. Co., Inc.
Lee Trailer & Body Co.
Sauerman Bros., Inc.
Sullivan Machinery Co.

C. D. Edwards Mfg. Co., Inc.
70 Fourth St., Lewis Bldg.

Feenaughty Machinery Co.
315 East Yamhill St.
The Baker Mfg. Co.
Littleford Bros.
The Universal Crane Co.

Fields Motor Company
16th and Alder Sts.
Ditwiler Manufacturing Co.

Frederick-Post Co.
91 Fifth St.
Buff & Buff Mfg. Co.

Gaddis & Dixon
474 Glisan St.
Page Steel & Wire Co.

A. C. Haag & Co., Inc.
170 E. Seventh St.
The Cleveland Tractor Co.

Harnischfeger Corporation
80 Fourth St.

P. R. Hines
208 Porter Bldg.
Williams Patent Crusher & Pulverizer Co.

Howard-Cooper Corporation
Third and Hawthorne Sts.
Barber-Greene Company
Ersted Manufacturing Co.
E. D. Etnyre & Co.
The Good Roads Machinery Co.
Orton Crane & Shovel Co.

International Harvester Co. of America, Inc.

J. L. Latture Equipment Co.
312 E. Madison St.
The Buffalo-Springfield Roller Company
Keystone Driller Company

Loggers & Contractors Machy. Company
70 Fourth St., Lewis Bldg.
The Fate-Root-Heath Co.
Harnischfeger Corporation
G. H. Williams Company

Mitchell, Lewis & Staver Co.
330 E. Morrison
Belle City Mfg. Co.

Pacific Building Materials Co.
210 Thompson St.
The Philip Carey Company

L. A. Snow Co.
Union Ave. at E. Main St.
Metal Forms Corporation

Earl B. Staley Co.
Adams and Pacific Sts.
Hydraulic Hoist Mfg. Co.

R. W. Wade & Company
The Roderick Lean Company

Willamette Equipment Co.
Foot of Curry St.
The Galion Iron Works & Mfg. Co.

Salem

A. C. Haag & Co., Inc.
444 Ferry St.
The Cleveland Tractor Co.

Pennsylvania

Allentown

V. H. Steckel
302 S. West St.
Hydraulic Hoist Mfg. Co.

Altoona

International Harvester Co. of America, Inc.

Bethlehem

The Barrett Company
c-o The Barrett Co., Hellertown

Bloomsburg

Whitenight & Kachinka
700 Market St.
The Cleveland Tractor Co.

Bradford

Bradford Supply Co.
130 Main St.
Domestic Engine & Pump Co.

Chambersburg

D. M. Bream Company
152 N. Second St.
The Cleveland Tractor Co.

Clark's Summit

Nichols Clark's Summit Garage
The Cleveland Tractor Co.

Easton

Sears & Bowers
Fourth and Spring Garden
The Cleveland Tractor Co.

Erie

J. F. Brittain
3001 Glenwood Park Ave.
The Cleveland Tractor Co.

Internation Harvester Co. of America, Inc.

The Pittsburgh Plate Glass Co.

John F. Steiner
1220 Sassafras St.
Domestic Engine & Pump Co.
O. K. Clutch & Machinery Co.

Hamburg

John H. Wertley
The Cleveland Tractor Co.

Harrisburg

The Galion Iron Works & Mfg. Co.
404 Telegraph Building

Henry Gilbert & Son
200 South 2nd St.
Domestic Engine & Pump Co.

Harrisburg Blue Print Co.
14 South Market Square
Buff & Buff Mfg. Co.

International Harvester Co. of America, Inc.

Lancaster

Herr "The Pump Man"
Ann and Fulton Sts.
Domestic Engine & Pump Co.

Lebanon

The Barrett Company
Berke and Dauphin Sts

M. A. Brightbill
21-23 Lehman St.
Ditwiler Manufacturing Co.

Mechanicsburg

Eastern Supply Company
Acme Road Machinery Co.

Mt. Carmel

William J. Edwards
Sullivan Machinery Co.

Oakdale

Lillo Bros. Company
Allegheny County
Asphalt Brick Company

Philadelphia

Austin-Western Road Machy. Co.
821 Widener Bldg.
Western Wheeled Scraper Co.

Barber-Greene Company
2401 Chestnut St.

The Barrett Company
36th St. and Gray's Ferry Ave.

L. R. Beatty
327 S. 12th St.
The Fate-Root-Heath Co.

Beckwith Machinery Co.
N. E. Cor. Front and Brown Sts.
Sauerman Bros., Inc.

Blaw-Knox Company
332 Widener Bldg.

Bucyrus-Erie Company
813 Commercial Trust

The Philip Carey Company
24th and Sedgley Ave.

Celite Products Company
Bulletin Bldg.

Concrete Steel Company
Pennsylvania Bldg.
Hoosier Asphalt Company

DeHuff & Hopkins
Morris Bldg.
Bay City Dredge Works

W. H. Dickson
1818 Widener Bldg.
Alan Wood Iron & Steel Co.

Eastern Body & Sales Co.
1615 East 20th St.
Ditwiler Manufacturing Co.

Edelen & Boyer Co.
236 No. 23rd St.
Heltzel Steel Form & Iron Co.

The Good Roads Machy. Co., Inc.
2037 Commercial Trust Bldg.
Rawls Manufacturing Co.

Harnischfeger Corporation
5102 Lancaster Ave.

The Heil Company
26th and Parrish Sts.

A. E. Hickey
3635 Lancaster Ave.
Fruehauf Trailer Company

Ingersoll-Rand Co.
Commercial Trust Bldg.

International Harvester Co. of America, Inc.

Inter-State Machinery Co.
Commercial Trust Bldg.
Keystone Driller Company

E. B. Kelley Co., Inc.
520 Arch St.
Heltzel Steel Form & Iron Co.

P. C. McKinlay
484 Bourse Bldg.
Williams Patent Crusher & Pulverizer Co.

Mallalieu & Conrey, Inc.
210 North 21st St.
The Roderick Lean Company

The Pittsburgh Plate Glass Co.

Horace T. Potts & Co.
East Erie Ave. and D St.
Page Steel & Wire Co.

W. L. Ridpath & Sons
Solvay Sales Corporation

Rodenhausen's Sales & Service Co.
1437 North Hutchinson St.
Hydraulic Hoist Mfg. Co.

Service Equipment Co.
211 North Third St.
O. K. Clutch & Machinery Co.

J. Jacob Shannon & Co.
1744 Market St.
G. H. Williams Company

Solvay Sales Corporation
437 Chestnut St.

Staley & Morris, Inc.
214 N. 22nd St.
Butler Bin Company
Domestic Engine & Pump Co.
Littleford Bros.
Metal Forms Corporation

Herbert N. Steinbarger Co.
1642 Wazee St.
Butler Bin Company

S. R. Vanderbeck
20 S. 15th St.
Orton Crane & Shovel Co.

F. Weber Company
Buff & Buff Mfg. Co.

Williams, Brown & Earle
918 Chestnut St.
Buff & Buff Mfg. Co.

Pittsburgh

Allegheny Equipment Co.
1606 Union Bank Bldg.
Sullivan Machinery Co.

C. H. Arnold Co.
Park Bldg.
George Haiss Mfg. Co., Inc.
Littleford Bros.

Barber-Greene Company
414 Bessemer Bldg.

Beck, Riley & Hall Equip. Co.
Union Trust Bldg.
G. H. Williams Company

Beckwith Machinery Co.
Arch St. and Parkway
The Baker Mfg. Co.
Hercules Motors Corporation
Sauerman Bros., Inc.
G. H. Williams Company

Brinker Supply Company
The Burch Corporation
Heltzel Steel Form & Iron Co.

Bucyrus-Erie Company
2211 Farmers Bank Bldg.

The Philip Carey Company
Corliss Station

Celite Products Company
Keenan Bldg.

Concrete Steel Company
Union Trust Bldg.
Hoosier Asphalt Company

Lynn Dix
1005 Park Bldg.
The Fate-Root-Heath Co.

Dravo Equipment Co.
Penn and Barbeau Aves.
Fruehauf Trailer Company
G. H. Williams Company

C. D. Edwards Mfg. Co., Inc.
403 Oliver Ave., Third Floor

B. K. Elliott Company
126 Sixth Street
Buff & Buff Mfg. Co.

Equipment Corp. of America
Empire Bldg.
G. H. Williams Company

Factory Products Company
5545 Darlington Road
The Universal Crane Co.

The Galion Iron Works & Mfg. Co.
341 Oliver Building

The Good Roads Machy. Co., Inc.
1523 Oliver Bldg.
Rawls Manufacturing Co.

Harnischfeger Corporation
Farmers Bank Bldg.

Hercules Body Sales Co.
Morewood at Center Ave.
Ditwiler Manufacturing Co.

Ingersoll-Rand Co.
706 Chamber of Commerce Bldg.

International Harvester Co. of America, Inc.

H. Kleinhans Company
Union Trust Bldg.
G. H. Williams Company

A. H. Krigger & Co.
House Bldg.
Orton Crane & Shovel Co.

Lakewood Engineering Co.
928 Behan St., N. S.
O. K. Clutch & Machinery Co.

Mayer Body Corporation
6461 Frankstown Ave.
The Heil Company

Martin J. O'Brien Co.
Union Bank Bldg.
Bay City Dredge Works

The Pittsburgh Plate Glass Co.

Reineke-Wagner Pump & Supply Company
416 First Ave.
Domestic Engine & Pump Co.

The Schnabel Company
South Tenth St.
Hydraulic Hoist Mfg. Co.

Solvay Sales Corporation
331 Fourth Ave.

Stewart-Holland Co., Inc.
Wabash Bldg.
Page Steel & Wire Co.

Sullivan Machinery Co.
Farmers Bank Bldg.

Ward Equipment Company
331 Fourth Ave.
Western Wheeled Scraper Co.

Western Wheeled Scraper Co.
324 Fourth Ave.

G. H. Williams Company
925 Union Trust Bldg.

Geo. W. Ziegler Machy. Co.
528 First Ave.
Butler Bin Company
The Cleveland Tractor Co.
Domestic Engine & Pump Co.
Metal Forms Corporation
G. H. Williams Company

Pittston

Penn State Equipment Co.
Newrose Bldg.
George Haiss Mfg. Co., Inc.

Plymouth

J. Frank Seeley & Son
32 Vine St.
Ditwiler Manufacturing Co.

Pottsville

Ingersoll-Rand Co.
304 West Market St.

Sullivan Machinery Co.
208 West Market St.

Scranton

The Bittenbender Company
126 Franklin Avenue
Page Steel & Wire Co.

H. N. Dean
208 Brooks Bldg.
Barber-Greene Company

Ingersoll-Rand Co.
610 Spruce St.

International Harvester Co. of America, Inc.

Rivenburg Blackwood Co.
306 Coal Exchange Bldg.
Williams Patent Crusher & Pulverizer Co.

H. G. Smith & Bros. Co.
1200 Wyoming Ave.
The Heil Company

Sullivan Machinery Co.
137 W. Adams Ave.

Shamokin

W. C. Hack & Sons
Sullivan Machinery Co.

Shenandoah

Union Hardware Co.
Sullivan Machinery Co.

Warren

The Pittsburgh Plate Glass Co.

Wilkes Barre

George R. Feldman Co.
2nd National Bank Bldg.
O. K. Clutch & Machinery Co.

Wyoming Utilities Co.
24 N. Washington St.
The Cleveland Tractor Co.

Williamsport

Industrial Trade Corporation
316 Government Place
George Haiss Mfg. Co., Inc.

International Harvester Co. of America, Inc.

York

Kelly Body Company
1537 W. Monroe St.
The Heil Company

Rhode Island

Eden Park

Waldo Bros. & Bond Co.
53 Oakland Ave.
Sullivan Machinery Co.

Providence

The Barrett Company

Dutee Wilcox Flint, Inc.
Lee Trailer & Body Co.

Hedge & Mattheis Co.
381 Promenade St.
Butler Bin Company
Littleford Bros.

International Harvester Co. of America, Inc.

Providence Body Co.
128 Narragansett Ave.
Hydraulic Hoist Mfg. Co.

Arthur E. Ray
516 Case Head Bldg.
The Heil Company

Waldo Bros. & Bond Co.
P. O. Box 1094
Sullivan Machinery Co.

South Carolina

Charleston

Gas Engine & Electric Co.
280 Meeting St.
Domestic Engine & Pump Co.

The Cameron & Barkley Co.
Domestic Engine & Pump Co.

Columbia

Caroline Contractor Equip. & Sup. Co.
P. O. 576
E. D. Etnyre & Co.
George Haiss Mfg. Co., Inc.

Construction Equipment Co.
1213 Lincoln St.
Harnischfeger Corporation

The Galion Iron Works & Mfg. Co.
330 Main St.

Gibbes Machinery Co.
Acme Road Machinery Co.
Bay City Dredge Works
The Cleveland Tractor Co.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

Jeff Hunt Road Machinery Co.
Domestic Engine & Pump Co.

International Harvester Co. of America, Inc.

Fred D. Marshall, Inc.
Seaboard Park (P. O. Box 1265)
O. K. Clutch & Machinery Co.
Rawls Manufacturing Co.
The Universal Crane Co.

Greenville

R. P. Sweeny Co
704 Chamber of Commerce Bldg.
Metal Forms Corporation

Spartanburg

R. W. Dodgen
The Buffalo-Springfield Roller Company

Standard Machinery & Equipment Company
Barber-Greene Company
Bucyrus-Erie Company
Butler Bin Company
Domestic Engine & Pump Co.
Heltzel Steel Form & Iron Co.
Littleford Bros.
Western Wheeled Scraper Co.
G. H. Williams Company

South Dakota

Aberdeen

International Harvester Co. of America, Inc.

Mound City

C. D. Edwards Mfg. Co., Inc.

Sioux Falls

Badger Body Mfg. Co.
Ditwiler Manufacturing Co.

Dennis Equipment Co.
822 N. Main Ave.
The Baker Mfg. Co.
The Cleveland Tractor Co.
Harnischfeger Corporation
Orton Crane & Shovel Co.

International Harvester Co. of America, Inc.

Sioux Falls Metal Culvert Co.
Armco Culvert Mfrs. Assn.

Western Material Company
533 E. 14th St.
Barber-Greene Company
Littleford Bros.

Watertown

J. I. Case Threshing Mach. Co.

International Harvester Co. of America, Inc.

Tennessee

Bristol

Drugan Motor Company
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

H. C. Purvine
111 East Fifth St.
Williams Patent Crusher & Pulverizer Co.

Chattanooga

L. J. Breed Equipment Co.
P. O. Box 1515, Station A
The Fate-Root-Heath Co.

Chattanooga Wagon & Body Co.
Ditwiler Manufacturing Co.

International Harvester Co. of America, Inc.

James Supply Company
1106-12 Market St.
The Philip Carey Company
Page Steel & Wire Co.

Mills & Lupton Supply Co.
1160 Market St.
Domestic Engine & Pump Co.
Heltzel Steel Form & Iron Co.
Sullivan Machinery Co.

Nixon-Haselle Co.
702 James Bldg.
George Haiss Mfg. Co., Inc.

Ortmeier Machinery Co.
1420 Williams St.
Hydraulic Hoist Mfg. Co.

Knoxville

Dempster Equipment Co.
The Cleveland Tractor Co.
Sullivan Machinery Co.
G. H. Williams Company

R. L. Harris
711 Jacksboro St.
The Baker Mfg. Co.
Bucyrus-Erie Company
Domestic Engine & Pump Co.
The Good Roads Machinery Co.
Western Wheeled Scraper Co.

A. G. Heins Company
116-126 Heins St.
The Philip Carey Company

Ingersoll-Rand, Inc.
Holston Nat'l Bank Bldg.

International Harvester Co. of America, Inc.

Knoxville Tool Die & Mchy. Co.
426 Maloney Ave.
Heltzel Steel Form & Iron Co.

Quality Body Co.
114 E. Vine St.
Hydraulic Hoist Mfg. Co.

W. J. Savage Company
Acme Road Machinery Co.
The Jos. Honhorst Co.

Sullivan Machinery Co.
623 Market St.

Memphis

Alton & Burge
245 Monroe Ave.
The Heil Company

Choctaw Culvert & Machinery Company
Second and Butler Sts.
Acme Road Machinery Co.
The Buffalo-Springfield Roller Company
The Burch Corporation
E. D. Etnyre & Co.
The Good Roads Machinery Co.
Heltzel Steel Form & Iron Co.
Littleford Bros.
The Universal Crane Co.

John C. Dix Son & Co.
235 Poplar Ave.
Ditwiler Manufacturing Co.

Fischer Lime & Cement Co.
263-295 Walnut St.
The Philip Carey Company

Harnischfeger Corporation
267 Union Ave.

International Harvester Co. of America, Inc.

James & Graham Wagon Co.
738 South Dudley St.
Fruehauf Trailer Company
Hydraulic Hoist Mfg. Co.

Memphis B. P. & Supply Co.
11 South Second St.
Buff & Buff Mfg. Co.

Memphis Tractor Co.
503 South Third St.
The Cleveland Tractor Co.

A. C. Miller
342 S. Main St.
George Haiss Mfg. Co., Inc.
O. K. Clutch & Machinery Co.

Miller-Cochran Company
704 Dermon Bldg., Cor. 3rd and Court
Page Steel & Wire Co.

Pidgeon-Thomas Iron Co.
Harnischfeger Corporation
Metal Forms Corporation

Percy F. Smith
1877 Snowden Ave.
Williams Patent Crusher & Pulverizer Co.

Robert G. Walls
Builders Exchange
The Fate-Root-Heath Co.
G. H. Williams Company

Western Wheeled Scraper Co.
91 South Front St.

Nashville

The Galion Iron Works & Mfg. Co.
111-3-5 Broadway

Harvill Supply Co.
413 Commerce St.
The Cleveland Tractor Co.

T. L. Herbert & Sons
174 Third Ave.
The Philip Carey Company

International Harvester Co. of America, Inc.

Logan Company
415 Chamber of Commerce
Page Steel & Wire Co.

Model Shops
100 Woodland St.
Hydraulic Hoist Mfg. Co.

Southland Motor & Body Corp.
Ditwiler Manufacturing Co.

The Tennessee Metal Culvert Co.
Armco Culvert Mfrs. Assn.

Wagner Sales Company
113 Fifth Ave., North
The Baker Mfg. Co.
The Universal Crane Co.

Wilson-Weesner-Wilkinson Co.
108 Fatherland St.
Barber-Greene Company
Littleford Bros.
Western Wheeled Scraper Co.

No. Chattanooga

Brown Craven Equipment Co.
706 Manning St.
Butler Bin Company

Texas

Amarillo

Amarillo Hardware Co.
Western Wheeled Scraper o.

Armstrong Transfer & Storage Company
Ditwiler Manufacturing Co.

Browning-Ferris Machinery Co.
1020 W. 6th St.
Heltzel Steel Form & Iron Co.
Littleford Bros.

J. I. Case Threshing Mach. Co.

International Harvester Co. of America, Inc.

Lewis-Patten Company
The Galion Iron Works & Mfg. Co.

Beaumont

Beaumont Export & Import Co.
403 Perlstein Bldg.
Acme Road Machinery Co.
George Haiss Mfg. Co., Inc

Norvell-Wilder Hardware Co.
Hercules Motors Corporation

E. L. Wilson Hardware Co.
Western Wheeled Scraper Co.

Borger

Western Supply Company
Hercules Motors Corporation

Dallas

The Barrett Company
P. O. Box 1035

J. W. Barthelow & Co.
1221 S. Lamar St.
Acme Road Machinery Co.
Domestic Engine & Pump Co.
E. D. Etnyre & Co.
The Fate-Root-Heath Co.
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.
Sullivan Machinery Co.
The Universal Crane Co.

Briggs Weaver Machinery Co.
Ersted Manufacturing Co.
Harnischfeger Corporation
G. H. Williams Company

Browning-Ferris Machinery Co.
205 Exposition Ave.
Barber-Greene Company
The Buffalo-Springfield Roller Company
Heltzel Steel Form & Iron Co.
Littleford Bros.
Orton Crane & Shovel Co.
Rawls Manufacturing Co.

J. I. Case Threshing Mach. Co.

Columbia Fence & Wire Co., Inc.
Page Steel & Wire Co.

C. M. Crookshank
1315 Santa Fe Bldg.
Alan Wood Iron & Steel Co.

C. D. Edwards Mfg. Co., Inc.
1813 Clarence St.

Edwards Wheel & Body Works
3900 East Side Ave.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

R. B. George Machinery Co.
302 North Market St.
The Baker Mfg. Co.

Harnischfeger Corporation
Construction Industries Bldg.

Huey & Philp Hardware Co.
Buff & Buff Mfg. Co.

Ingersol-Rand Co. of Texas
Magnolia Bldg.

International Harvester Co. of America, Inc.

Lewis-Patten Company
The Galion Iron Works & Mfg. Co.

The Pittsburgh Plate Glass Co.

Rogers Asbestos Co., Inc.
1103 Main St.
The Philip Carey Company

Geo. W. Smith Co.
521 S. Arkard St.
Metal Forms Corporation

Sullivan Machinery Co.
522 Santa Fe Bldg.

Texas Motor Truck & Parts Co.
West End Commerce Viaduct
Hydraulic Hoist Mfg. Co.

Western Metal Mfg. Co.
Armco Culvert Mfrs. Assn.

Western Wheeled Scraper Co.
1301 South Lamar St.

El Paso

Continental Importing & Exporting Co.
Williams Patent Crusher & Pulverizer Co.

Denver Fire Clay Co.
209 Mills Bldg.
Solvay Sales Corporation

Gasner Bros.
413 Yandell Blvd.
Ditwiler Manufacturing Co.

Ingersol-Rand Co. of Texas
718 Mills Building

International Harvester Co. of America, Inc.

Sheehan & Company
1615 Bassett St.
Acme Road Machinery Co.
Barber-Greene Company
The Cleveland Tractor Co.
E. D. Etnyre & Co.
Heltzel Steel Form & Iron Co.
Hercules Motors Corporation
O. K. Clutch & Machinery Co.
Rawls Manufacturing Co.
Sauerman Bros., Inc.

Steel Products Corporation
1125 Texas St.
Bay City Dredge Works
Domestic Engine & Pump Co.
The Fate-Root-Heath Co.
The Galion Iron Works & Mfg. Co.
George Haiss Mfg. Co., Inc.

Sullivan Machinery Co.
511 Mills Bldg.

Western Metal Mfg. Co.
Armco Culvert Mfrs. Assn.

Ft. Worth

J. W. Bartholow Co.
1704 Jones St.
Domestic Engine & Pump Co.
Sauerman Bros., Inc.
The Universal Crane Co.

Browning-Ferris Machy. Co.
9th & Jones Sts.
Heltzel Steel Form & Iron Co.

C. B. Caswell
709-11 North Main St.
Fruehauf Trailer Company

International Harvester Co. of America, Inc.

Norvell-Wilder Hardware Co.
Hercules Motors Corporation

Houston

Alamo Iron Works
Butler Bin Company

Alamo Steel & Supply Co.
Bucyrus-Erie Company

Browning-Ferris Machinery Co.
2200 McKinney Ave.
Heltzel Steel Form & Iron Co.
Littleford Bros.

Celite Products Company
314 West Bldg.

Edwards Wheel & Body Works
Ditwiler Manufacturing Co.

B. M. Estes
1429 Allston St.
Williams Patent Crusher & Pulverizer Co.

R. B. Everett & Co.
3112 Harrisburg Blvd.
Barber-Greene Company
Bay City Dredge Works
The Buffalo-Springfield Roller Company
E. D. Etnyre & Co.
Harnischfeger Corporation
Sullivan Machinery Co.

F. W. Gartner
P. O. Box 1303
Acme Road Machinery Co.
The Burch Corporation
The Fate-Root-Heath Co.
George Haiss Mfg. Co.
The Jos. Honhorst Co.

R. B. George Machinery Co.
Wood and Walnut Sts.
The Baker Mfg. Co.

International Harvester Co. of America, Inc.

Joseph F. Meyer Company
Western Wheeled Scraper Co.

Norvell-Wilder Hardware Co.
Hercules Motors Corporation

Rogers Asbestos Co., Inc.
5 Live Oak St.
The Philip Carey Company

South Texas Imp. & Machy. Co.
Wood and N. San Jacinto Sts.
Domestic Engine & Pump Co.
The Galion Iron Works & Mfg. Co.

Texas B. P. & Supply Co.
420 Fannin St.
Buff & Buff Mfg. Co.

Vincent A. Tozzi Company
2nd National Bank Bldg.
Page Steel & Wire Co.

Western Metal Mfg. Co.
Armco Culvert Mfrs. Assn.

Woodward-Wight & Co., Ltd.
Ersted Manufacturing Co.

San Antonio

Alamo Iron Works Co.
Bucyrus-Erie Company
Butler Bin Company
G. H. Williams Company

G. B. Chadwick
125 Blue Star St.
Barber-Greene Company

Edwards Wheel & Body Works
Ditwiler Manufacturing Co.

James W. Francis Co.
1113-15 W. Houston St.
The Cleveland Tractor Co.
George Haiss Mfg. Co., Inc.

R. B. George Machinery Co.
1337½ South Flores St.
The Baker Mfg. Co.

International Harvester Co. of America, Inc.

Lewis-Patten Company
423 Hoefgen Ave.
The Galion Iron Works & Mfg. Co.

Neal & Henderson
Western Wheeled Scraper Co.

The Pittsburgh Plate Glass Co.

Southern Steel Company
4700 S. Presa St.
Page Steel & Wire Co.

Sherman

Hardwicke-Etter Company
Hercules Motors Corporation

Waco

D. June Machinery Co.
Sullivan Machinery Co.

Utah

Ogden

R. T. Mitchell Co.
2331 Kiesel Ave.
The Cleveland Tractor Co.

Salt Lake City

Allen Equipment Co.
46 W. 4th South
The Roderick Lean Company

The Barrett Company
10th West & South Temple St.
P. O. Box 985

J. I. Case Threshing Mach. Co.

Denver Fire Clay Co.
155 W. 2nd South St.
Solvay Sales Corporation

The Galigher Company
228 S. W. Temple St.
The Philip Carey Company
Rawls Manufacturing Co.

Gates & Glassbrook
201 Dooly Block
Sauerman Bros., Inc.

Ingersoll-Rand Co.
51 W. S. Temple St.

International Harvester Co. of America, Inc.

C. H. Jones & Co.
206 S. W. Temple St.
The Baker Mfg. Co.
Ersted Manufacturing Co.
The Galion Iron Works & Mfg. Co.
Metal Forms Corporation
O. K. Clutch & Machinery Co.

Landes & Company
246 W. S. Temple
The Fate-Root-Heath Co.
George Haiss Mfg. Co., Inc.
Harnischfeger Corporation
Western Wheeled Scraper Co.

Lund & Company
419 Dooly Block
Barber-Greene Company
E. D. Etnyre & Co.
Hydraulic Hoist Mfg. Co.
Littleford Bros.

National Equipment Co.
101 W. 2nd South St.
Bucyrus-Erie Company

Nickerson Machinery Co.
151 W 2nd South St.
Hercules Motors Corporation

The Pittsburgh Plate Glass Co.

F. C. Richmond Machinery Co.
117 W. 2nd South St.
Keystone Driller Company
Orton Crane & Shovel Co.
Williams Patent Crusher & Pulverizer Co.

Stannard Machinery Co.
604 Dooly Block
The Buffalo-Springfield Roller Company
Butler Bin Company

Streator-Smith, Inc.
47 W. 4th South St.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

Sullivan Machinery Co.
117 W. 2nd South St.

Waterworks Equipment Co.
149 W. 2nd South St.
G. H. Williams Company

Woods Cross

The Burnham Mfg. Co.
Armco Culvert Mfrs. Assn.
Page Steel & Wire Co.

Vermont

Barre

Granite City Tool Co.
Sullivan Machinery Co.

St. Johnsbury

International Harvester Co. of America, Inc.

White River Junction

Miller Automobile Co.
Gates St.
The Cleveland Tractor Co.

Virginia

Danville

Tomkins Chevrolet Co.
Ditwiler Manufacturing Co.

Vass-Mobley Hardware Company
Page Steel & Wire Co.

Falls Church

Allan P. Wilson
Metal Forms Corporation

Norfolk

Concrete Steel Company
400 Board of Trade Bldg.
Hoosier Asphalt Company

General Utilities Company
Box 361
Barber-Greene Company
The Fate-Root-Heath Co.
Heltzel Steel Form & Iron Co.
O. K. Clutch & Machinery Co.
Ryan Manufacturing Corp.

International Equip. Co.
916 Main Street
Bay City Dredge Works

The Pittsburgh Plate Glass Co.

E. E. Springer
1314 Stockley Gardens
Fruehauf Trailer Company

The Henry Walke Co.
407 Union St.
Domestic Engine & Pump Co.

Richmond

Baker Equip. & Eng. Co.
Ditwiler Manufacturing Co.

Graham B. Bright Co.
901 Electric Bldg.
Acme Road Machinery Co.
Butler Bin Company
E. D. Etnyre & Co.
Sullivan Machinery Co.

The Philip Carey Company
1719 Summit Ave.

Earnest Brothers
Keystone Driller Company

Geo. E. Hoppe
801 McDonough St.
George Haiss Mfg. Co., Inc.

John L. Kelleher
322 American Nat'l Bank Bldg.
Fruhauf Trailer Company

Hening & Nukols
Western Wheeled Scraper Co.

International Harvester Co. of America, Inc.

Ed. P. Phillips
505 Mutual Bldg.
Metal Forms Corporation
The Universal Crane Co.

Jos S. Potts Jr. & Co.
512 Travelers Bldg.
Bucyrus-Erie Company
G. H. Williams Company

Richmond Machinery & Equip. Company
Page Steel & Wire Co.

J. G. Skelton Company
Electric Bldg.
Orton Crane & Shovel Co.

Smith-Moore Vehicle Co.
408 North 5th Street
The Heil Company

Virginia Tractor Co.
N. Blvd. opp. Fair Grounds
Domestic Engine & Pump Co.
Harnischfeger Corporation
The Jos. Honhorst Co.

W. S. White
12 N. Fifteenth St.
The Buffalo-Springfield Roller Co.

Roanoke

The Galion Iron Works & Mfg. Co.
312-14-16 Mountain Ave., S. E.

Noland Company, Inc.
Domestic Engine & Pump Co.

Roanoke Motor Company
Ditwiler Manufacturing Co.

Roanoke Sales Corp.
Mountain Ave. & 3rd St., S. E.
The Baker Mfg. Co.
The Burch Corporation
The Cleveland Tractor Co.
Littleford Bros.

Roanoke Welding Co.
16 Kirk Ave.
Hydraulic Hoist Mfg. Co.

Southern Machy. & Supply Co.
307 Liberty Trust Bldg.
George Haiss Mfg. Co., Inc.

Virginia Culvert Corporation
Armco Culvert Mfrs. Assn.

Washington

Seattle

Austin-Western Road Machy. Co.
Western Wheeled Scraper Co.

Balfour Guthrie Co.
1425 Dexter Horton Bldg.
Solvay Sales Corporation

Jerry Caldwell Company
1040 Sixth Ave., S.
The Galion Iron Works & Mfg. Co.
Harnischfeger Corporation
O. K. Clutch & Machinery Co.

Celite Products Company
1212 Sixth Ave., South

Clyde Equipment Co.
3410 First Ave. S.
Bucyrus-Erie Company
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.
Sullivan Machinery Co.

A. H. Cox & Company
1757 First Ave., South
Butler Bin Company
Ersted Manufacturing Co.
The Fate-Root-Heath Co.
G. H. Williams Company

C. D. Edwards Mfg. Co., Inc.
Polson Implement Co.

Feenaughty Machinery Co.
1028 Sixth Ave., South
The Universal Crane Co.

P. L. Francis
909 Dexter Horton Bldg.
Alan Wood Iron & Steel Co.

Gaddis & Dixon
2203 First Ave., South
Page Steel & Wire Co.

Harnischfeger Corporation
534 First Ave., South

Hills-Mills Company
2905 First Ave., South
The Cleveland Tractor Co.

Howard-Cooper Corporation
1041 Sixth Ave., South
Barber-Greene Company
Western Crucible Steel Casting Co.

Ingersoll-Rand Co.
526 First Ave., South

W. J. Ranken
906½ Fourth Ave.
Buff & Buff Mfg. Co.

George Scofield Company
1733 Westlake Ave., North
The Philip Carey Company

L. A. Snow Co.
1032 Sixth Ave., South
Metal Forms Corporation

Earl B. Staley Co.
911 Eleventh Ave.
Hydraulic Hoist Mfg. Co.

Star Machinery Company
(W. A. Farris)
Fruehauf Trailer Company

C. H. Wells, Inc.
907 E. Pike St.
Ditwiler Manufacturing Co.

Arthur W. Wilde
Dexter Horton Bldg.
Williams Patent Crusher & Pulverizer Co.

Spokane

J. I. Case Threshing Mach. Co.

Feenaughty Machinery Co.
South 121 Madison St.
The Universal Crane Co.

General Machinery Co.
E. 3500 Riverside Drive
Acme Road Machinery Co.
The Galion Iron Works & Mfg. Co.
Harnischfeger Corporation
Hercules Motors Corporation

Hills-Mills Company
918 West First Ave.
The Cleveland Tractor Co.

Hofius-Ferris Equipment Co.
1118 Ide Ave.
The Buffalo-Springfield Roller Co.
Ersted Manufacturing Co.
The Fate-Root-Heath Co.
Metal Forms Corporation
G. H. Williams Company

International Harvester Co. of America, Inc.

Spokane Culvert & Tank Co.
Armco Culvert Mfrs. Assn.
Page Steel & Wire Co.

Sullivan Machinery Co.
120 S. Lincoln St.

Wells Chevrolet Co.
1215 First Ave.
Ditwiler Manufacturing Co.
Lee Trailer & Body Co.

D. A. Whitley
206 W. Garland Ave.
Hydraulic Hoist Mfg. Co.

Tacoma

Balfour Guthrie Co.
Solvay Sales Corporation

George Scofield Company
1533 Dock St.
The Philip Carey Company

West Virginia

Bluefield

Bluefield Supply Co.
Domestic Engine & Pump Co.
G. H. Williams Company

City Chevrolet Sales Co.
620 Raleigh St.
Ditwiler Manufacturing Co.

Philip Kleiman
217 Princeton Ave.
Buff & Buff Mfg. Co.

Superior Supply Co.
Sullivan Machinery Co.

Cameron

Cameron Tool & Supply Co.
Domestic Engine & Pump Co.

Charleston

Baldwin Supply Company
Sullivan Machinery Co.

Butler Chevrolet Co.
1016 Lee St.
Ditwiler Manufacturing Co.

Hydraulic Hoist & Body Co.
83rd and Charleston Sts.

E. H. Morford Co.
52 Citizens Nat'l Bank Bldg.
Acme Road Machinery Co.

Clarksburg

General Equipment Co.
414 North Fourth St.
O. K. Clutch & Machinery Co

W. Va. Mine Supply Co.
The Buffalo-Springfield Roller Co.
Domestic Engine & Pump Co.
Heltzel Steel Form & Iron Co.

Huntington

Bailey Hall Machinery Co.
20th St. and B. & O. R. R.
The Burch Corporation
The Universal Crane Co.

Banks-Miller Supply Co.
742 Third Ave.
The Philip Carey Company
The Jos. Honhorst Co.
Littleford Bros.
Metal Forms Corporation
Rawls Manufacturing Co.
Western Wheeled Scraper Co.

La Lance Equipment Co.
747 Third Ave.
Barber-Green Company
The Buffalo-Springfield Roller Co.
The Fate-Root-Heath Co.

Porter Supply Co.
1st Huntington Nat'l Bank
Bucyrus-Erie Co.
Domestic Engine & Pump Co.
The Galion Iron Works & Mfg. Co.
Heltzel Steel Form & Iron Co.
Sullivan Machinery Co.

Rich Chevrolet Co.
533 Fourth Ave.
Ditwiler Manufacturing Co.

Sullivan Machinery Co.
736 Third Ave.

Logan

Logan Hardware & Supply Co.
Orton Crane & Shovel Co.

Parkersburg

International Harvester Co. of America, Inc.

Parkersburg Automobile Co.
712 Market St.
Ditwiler Manufacturing Co.

Parkersburg Supply Co.
314 Fourth St.
Page Steel & Wire Co.

Wheeling

C. F. Braunlich & Co.
1012 Market St.
Domestic Engine & Pump Co.

The Philip Carey Company
Chapline at 18th St.

C. D. Edwards Mfg. Co., Inc.
P. O. Box 341

Williamson

Williamson Supply Co.
Domestic Engine & Pump Co.

Wisconsin

Eau Claire

Bark River Bridge & Culvert Co.
Armco Culvert Mfrs. Assn.

International Harvester Co. of America, Inc.

Fond du Lac

T. W. Meiklejohn Co.
Belle City Mfg. Co.

Green Bay

International Harvester Co. of America, Inc.

P. F. Suess Mach. Exchange
Cor. Pearl and Howard Sts.
Bay City Dredge Works

Hurley

Twin City Iron Works
Western Crucible Steel Casting Co.

Janesville

J. A. Strimple Co.
219 Milwaukee Ave.
Ditwiler Manufacturing Co.

Supreme Safety Service Co.
Lee Trailer & Body Co.

Kenosha

MacWhyte Company
2906 14th Ave.
Hubbard & Company

Madison

International Harvester Co. of America, Inc.

M. D. Ratcliff
Acme Road Machinery Co.

Wisconsin Crawler Tractor Co.
25 North Charter St.
The Cleveland Tractor Co.

Milwaukee

E. P. Barnett
846 41st St.
Fruehauf Trailer Company

The Barrett Company
200 30th St., N. Milwaukee

Boehck Machinery Co., Inc.
2404-06 Clybourn St.
G. H. Williams Company

Chadwick Brothers
25th and Clybourn Sts.
Barber-Greene Company
Heltzel Steel Form & Iron Co.

Concrete Steel Company
1201 Trust Company Bldg.
Hoosier Asphalt Company

Cunningham-Ortmayer Co.
15 Michigan St.
Butler Bin Company
Ersted Manufacturing Co.
The Galion Iron Works & Mfg. Co.
Rawls Manufacturing Co.
The Universal Crane Co.
Western Crucible Steel Casting Co.

E. A. Drott Tractor Co.
6079 Plankinton Bldg.
The Baker Mfg. Co.

Engineers and Contractors Supply Co.
228 Third St.
O. K. Clutch & Machinery Co.

Harnischfeger Corporation
38th and National Ave.

Hunter Machinery Co.
Sixteenth St. Viaduct
The Buffalo-Springfield Roller Co.
Sauerman Bros., Inc.
Sullivan Machinery Co.
Western Wheeled Scraper Co.

International Harvester Co. of America, Inc.

Mullins Body & Tank Co.
47th and Rogers
Ditwiler Manufacturing Co.

Perfex Corporation

The Pittsburgh Plate Glass Co.

H. Y. Smith Company
1301 First Nat'l Bank Bldg.
Orton Crane & Shovel Co.

A. F. Wagner Architectural Works
763 North Water St.
Page Steel & Wire Co.

Racine

J. I. Case Threshing Machine Co.

Waukesha

The I. B. Rowell Co.
The Roderick Lean Company

Whitewater

Whitewater Bridge Company
Rawls Manufacturing Co.

Wyoming

Cheyenne

International Harvester Co. of America, Inc.

Canada

Alberta

Calgary

J. I. Case Threshing Machine Co.

International Harvester Co. of America, Inc.

Riverside Iron Works, Ltr.
410 Riverside Blvd. S. E.
Harnischfeger Corporation

Edmonton

International Harvester Co. of America, Inc.

Lethbridge

International Harvester Co. of America, Inc.

British Columbia

Vancouver

Brown-Fraser Co., Ltd.
1150 Homer St.
Bay City Dredge Works
The Fate-Root-Heath Co.
The Galion Iron Works & Mfg. Co.
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.

Federal Parts & Equip. Co.
1295 Seymour St.
Hydraulic Hoist Mfg. Co.

International Harvester Co. of America, Inc.

Mussens, Ltd.
611 Credit Foncier Bldg.
Barber-Greene Company
Bucyrus-Erie Company
Heltzel Steel Form & Iron Co.
Western Wheeled Scraper Co.

Sullivan Machinery Co.
633 Howe St.

Willard Equipment Co., Ltd.
860 Beach Ave.
Rawls Manufacturing Co.

Manitoba

Brandon

International Harvester Co. of America, Inc.

Winnipeg

J. H. Ashdown Hardware Co.
Page Steel & Wire Co.

J. I. Case Threshing Machine Co.

Dominion Equip. & Supply Co.
Commercial Bldg.
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.

International Harvester Co. of America, Inc.

Mussens, Ltd.
Barber-Greene Company
Bucyrus-Erie Company
Heltzel Steel Form & Iron Co.

Powell Equipment Co.
1056 Arlington St.
Butler Bin Company
The Fate-Root-Heath Co.
Littleford Bros.

Western Steel Products, Ltd.
The Philip Carey Company

New Brunswick

St. John

Gandy & Allison, Ltd.
Page Steel & Wire Co.

International Harvester Co. of America, Inc.

Nova Scotia

Halifax

Chas Fowler (Mack Dealer)
Tramway Bldg.
The Heil Company

Wm. Stairs, Son & Morrow Co.
The Baker Mfg. Co.

Ontario

Guelph

Canada Ingot Iron Co., Ltd.
Armco Culvert Mfrs. Assn.

Hamilton

International Harvester Co. of America, Inc.

London

International Harvester Co. of America, Inc.

Niagara Falls

Dominion Chain Co., Ltd.
Page Steel & Wire Co.

Ottawa

International Harvester Co. of America, Inc.

Toronto

Canadian Johns-Manville Co.
19 Front St.
The Jos. Honhorst Co.

J. I. Case Threshing Machine Co.

F. H. Hopkins & Co., Ltd.
109 Mail Bldg.
Butler Bin Company
The Fate-Root-Heath Co.
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.

J. S. Innes
1109 Federal Bldg.
Rawls Manufacturing Co.

International Harvester Co. of America, Inc.

Mussens, Ltd.
4 Richmond St., East
Barber-Greene Company
Bucyrus-Erie Company
Heltzel Steel Form & Iron Co.
Sauerman Bros., Inc.
Western Wheeled Scraper Co.

Ontario Tractor Co., Ltd.
297 Campbell Ave.
The Baker Mfg. Co.

Clare Osborn, Ltd.
Spadina and Fleet Sts.
Bucyrus-Erie Company

The Pittsburgh Plate Glass Co.

Robt. T. Purves & Company
96-98 Vine St., West Ontario
The Philip Carey Company

Sullivan Machinery Co.
37 Colborne St.

Quebec

Montreal

Asbestos, Ltd.
1-3-3A McCord St.
The Philip Carey Company

Canadian Fairbanks-Morse Co.
84 St. Antoine St.
The Jos. Honhorse Co.

Canadian Mead-Morrison Co.
Canada Cement Bldg.
Mead-Morrison Mfg. Co.

Celite Products Company
New Birks Bldg.

Clare Osborn, Ltd.
811 Keefer Bldg.
Bucyrus-Erie Company

General Construction Material Co., Ltd.
Acme Road Machinery Co.

Francis Hankin & Co., Ltd.
598-604 Union Ave.
Littleford Bros.

F. H. Hopkins & Co.
Imperial Bank Bldg.
The Baker Mfg. Co.
Bay City Dredge Works
Butler Bin Company
The Fate-Root-Heath Co.
George Haiss Mfg. Co., Inc.
Sauerman Bros., Inc.

International Harvester Co. of America, Inc.

H. Smith Johannsen
1433 Bishop St.
The Universal Crane Co.

Lamoureaux-Kelly, Ltd.
(Fred Lamoureaux)
Fruehauf Trailer Company

Montreal Wire Works, Ltd.
50 Craig Street, West
Page Steel & Wire Co.

Mussens, Ltd.
41 Phillips Place Bldg.
Barber-Greene Company
Bucyrus-Erie Company
Heltzel Steel Form & Iron Co.
Western Wheeled Scraper Co.

The Pittsburgh Plate Glass Co.

Winn & Holland, Ltd.
407 McGill St.
Solvay Sales Corporation

Quebec City

International Harvester Co. of America, Inc.

Montreal Wire Works, Ltd.
21 St. Peter St.
Page Steel & Wire Co.

Saskatchewan

Estevan

International Harvester Co. of America, Inc.

No. Battleford

International Harvester Co. of America, Inc.

Regina

J. I. Case Threshing Machine Co.

International Harvester Co. of America, Inc.

Saskatoon

J. I. Case Threshing Machine Co.

International Harvester Co. of America, Inc.

Yorkton

International Harvester Co. of America, Inc.

Cuba

Havana

Castellanos, Vigil & Cia
Manzana de Gomez 269-270
P. O. Box 325
The Philip Carey Company

Ellis Bros., Inc.
Cuba y Lamparilla
George Haiss Mfg. Co., Inc.
Western Wheeled Scraper Co.

Havana Fruit Company
Barber-Greene Company
Harnischfeger Corporation
Littleford Bros.
Rawls Manufacturing Co.

E. N. Villa
Virtudes 177 A
E. D. Etnyre & Co.

Hawaii

Hilo

Honolulu Iron Works Co.
Littleford Bros.

Honolulu

Theo. H. Davies & Co., Ltd.
The Baker Mfg. Co.

Grace Brothers
Barber-Greene Company

Honolulu Iron Works Co.
Littleford Bros.

Philippine Islands

Manila

The Earnshaws Docks & Honolulu Iron Works
110 Second St., New Port Area
Littleford Bros.

Manila Machy. & Supply Co., Inc.
517-19 Dasmarinas
Western Wheeled Scraper Co.

BUFF & BUFF MFG. CO.

Jamaica Plain Station, Boston, Mass.

Manufacturers of Surveying Instruments

New York Office: Hudson Terminal, 46 Dey Street. **Chicago Office:** 314 Institute Place.

Products: "BUFF" TRANSITS AND LEVELS.

Also manufacturers of Theodolites, Tripods, Levelling Rods, Plumb Bobs, Plummet Lamps, Steel Tapes, Range Poles, Marking Pins and Current Meters.

Repairs to Instruments: "Buff" transits, solidly built to resist blows and falls, have metal generously distributed throughout the construction.

At the Jamaica Plain shops, all makes are repaired with economy and despatch. Injured parts of instruments are duplicated from stock in hand. Telegraph orders can be completed in 24 hours.

Specifications 6¼-inch Buff "Precise" Transit No. 1B: Graduation, 6¼-in. diameter, with two opposite double reading verniers to minutes, placed at either 30° or 90° to line of sight. Two rows of opposite inclined figures 0-360. Graduations silver and covered by pure crystal plate glass.

Telescope, erecting, is balanced and reverses at either end; 12 in. long, 1¼-in. aperture, with power of 26.5 diameter improved eyepiece, unsurpassed large clear field. Center point is provided on top of telescope to permit of accurate centering from above. Adjustment for vertical plane, and line of collimation correct for all distances. Sensitive level bubble, 6 in. long, with clamp and tangent to telescope. Improved lower and upper spring tangent clamps. Shifting center with ¾-in. adjustment. Spirit levels truly ground by special machine, rated and sensitive. Standards are leather finished. Long taper centers with broad flanges and of hardest bell-metal and phosphor bronze. Compass needle is 4½ in. long and of accepted form. Compass graduation is silvered and figured with a single row 0-90 on each side of N. and S. Tripod improved, split-leg with wing-nuts, weight 7½ lbs.

Mahogany instrument box is provided with strap, brass lock and hooks; contains plumb bob, pocket magnifier, sunshade, wrench, screwdriver, adjusting pins, etc.

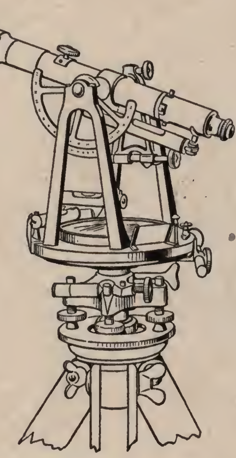
Engineers' Levels: 18-inch Wye Level—Telescope, 18 in.; 1⅜-in. objective; 36 power; protection to object slide; erecting eyepiece. Telescope and level tube, leather finished. Phosphor bronze contact points in wyes for bell-metal collars; hard bell-metal center in socket of phosphor bronze. Line of collimation correct for all distances. Adjusted to finest possible accuracy with sunshade in position and focused on mean distance. Mahogany case with strap and hooks, sunshade, wrench, screwdriver, adjusting pin, etc.
Weight, 10¾ lbs.; tripod, 7 lbs.
Also we make 15-inch Dumpy Level of new design.

References: This company are Instrument Makers to the United States Government, many departments; New York Central R. R.; New York, New Haven & Hartford R. R.; New York Water Board; Public Service Commission and Board of Public Works, New York City; Standard Oil Co.; Guggenheim and Rothschild interests; J. G. White Co., and numberless other engineering organizations. The Pennsylvania R. R. used "Buff" instruments in large numbers in both their North River and East River tunnels. The Subway Commission of New York is now using 450 "Buff" instruments.

On all Transits we now supply the patented friction brake to prevent telescope flopping and double lock nut adjustment for standards.

Super-"Precise" Transits

Size	No. 1	No. 2	No. 3	No. 4
Weight ....lb.	13½	10	7	5
Diameter of graduation....in.	6¼	5⅛	4½	4
Length of Needle....in.	4½	3¾	3¼	2½
Power erecting telescope, diam....	26.5	22.5	18	17
Power inverting telescope, diam....	29	25	21	20
Length of telescope....in.	12	10¾	8	8
Length level bubble....in.	6	5½	4	4
Diameter telescope aperture....in.	1¼	1¼	1⅛	1⅛



6¼-Inch Buff "Precise" Transit No. 1B

Patented Nov. 6, 1900; Nov. 13, 1900; Feb. 3, 1903; July 11, 1916

Catalogues: Complete catalog 26 sent on request, also copy of adjustment book sent gratis on request.

To engineers mentioning Road and Street Catalog we will, on request, mail a 4-inch high bas-relief of nickel-silver—being an exact likeness of the "Engineer's Best Friend"—"the Buff Transit."

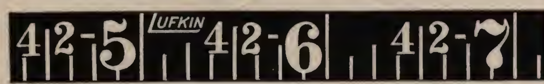
THE LUFKIN RULE CO.

Saginaw, Michigan

Manufacturers of Measuring Tapes and Rules of All Kinds

BRANCHES: New York. Windsor, Ont.

LUFKIN
Trade-Mark



***"Challenge" Steel Tapes:** Suitable for any measuring. ⅜ and ½ inch wide steel line, marked feet, inches and 8ths. Well built, metal-lined, genuine leather case, with push button. Many highway people prefer the ½ inch tape, and we recommend it for this heavy duty.

Length, feet	25	50	75	100
⅜ inch tape, No.	260	263	265	266
List price, each	$4.90	$6.00	$7.80	$10.20
½ inch tape, No.	360	363	365	366
List price, each	$5.60	$6.75	$9.00	$11.25

*Furnished at same price marked feet, 10ths and 100ths. Specify as 260D, 360D, etc.

Engineer's Pattern Steel Tapes: A sturdy tape and case, designed for heavy, yet precise work. ¼ inch heavy steel line of engineer's pattern, marked either feet, 10ths and 100ths, or feet, inches and 8ths. Metal-lined genuine leather case with push button. Tape readily detached from case and furnished with two detachable rings.

Grad. 10ths, No.	233D	234D	235D	236D
Grad. inches, No.	233	234	235	236
Length, feet	50	66	75	100
List price, each	$8.75	$11.30	$12.50	$15.60

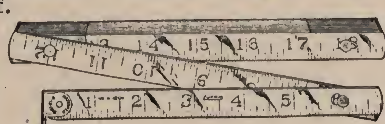
This Engineer's line also furnished in open metal reel, "Wolverine" Pattern.

Metallic Tapes: Widely used, highest grade woven tape, ⅝ inch wide linen line with metallis strands; marked feet and inches. Metal-lined case of genuine leather, with substantial folding handle. Patent threader makes removal of old and attaching of new line most simple.

Length, feet	25	50	75	100
Tape with case, No.	500	503	505	506
List price, each	$3.10	$4.50	$5.60	$7.00
Tape line only, No.	0500	0503	0505	0506
List price, each	$1.45	$2.50	$3.25	$4.70

Note: Tapes marked feet and 10ths of feet, same price.

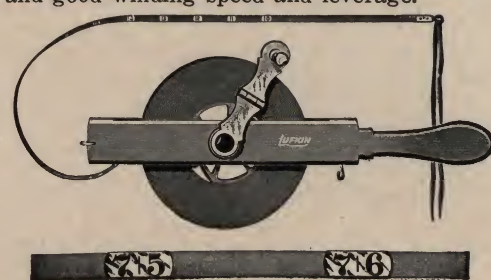
Folding Aluminum Rules: Accurate—Light-weight. Durable—Rust-proof.



No. 1203 Series Aluminum Rules, Marked inches to 16ths, on both sides.

No. 1203—3 feet, per doz.	$12.60
No. 1204—4 feet, per doz.	16.80
No. 1205—5 feet, per doz.	21.00
No. 1206—6 feet, per doz.	25.20
Extra for Folding Hook on above rules, per doz.	$1.20

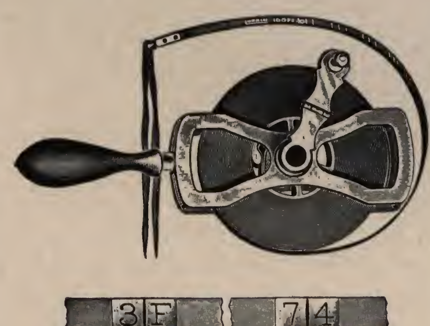
†Etched Chain Tapes: A ¼ inch extra heavy steel tape for road or cross-country work. Having etched marking every foot with end feet to 100ths, this tape affords a fine degree of accuracy. Line readily detached from reel and supplied with two rawhide thongs. Open reel of hardwood allows for dirt accumulation, gives firm grip and good winding speed and leverage.



No.	5100	5150	5200	5300
Length, feet	100	150	200	300
List price, each, tape complete	$10.50	$14.00	$16.50	$25.00
List price, each, line only	7.00	9.80	12.25	18.70

†For measurements beginning at outside end of ring add to the stock number the suffix "A", as No. 5100A. Also supplied in 1 and 2 chain lengths, marked in links and poles (rods).

†"Michigan" Chain Tapes: Graduations on Babbitt Metal. A tape of extraordinary durability, designed for rough work. $\frac{5}{16}$ inch wide steel tape marked feet only, end feet to 10ths. Line detachable from reel and supplied with two rawhide thongs. Metal reel with hardwood handle is sturdy and affords good grip, leverage and speed in winding.

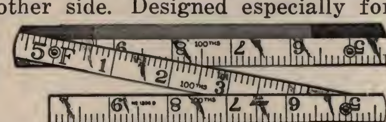


No.	3100	3150	3200	3300	3500
Length, feet	100	150	200	300	500
List price, each, tape complete	$9.00	$12.00	$14.10	$21.25	$33.00
List price, each, line only	6.00	8.40	10.50	15.90	27.00

†For measurements beginning at outside end of ring add to the stock number the suffix "A", as No. 3100A. Also supplied in 1 and 2 chain lengths, marked in links and poles (rods).

Folding Aluminum Rules:

No. 1306D, marked feet, 10ths and 100ths one side, feet, inches and 16ths, other side. Designed especially for Highway Builders, Surveyors, Civil Engineers, and Tile Layers use.



No. 1306D—6 feet, per doz.	$25.20
Extra for Folding Hook on above rules, per doz.	$1.20

Also full lines of Genuine Stainless Steel Tapes, Spring Joint Rules, Boxwood and Steel Rules.

EUGENE DIETZGEN CO.

Manufacturers of Drafting and Surveying Supplies

Chicago, 166 W. Monroe.
New York, 218 E. 23rd St.
New Orleans, 316 Camp St.

Pittsburgh, 805 Liberty Ave.
Philadelphia, 1521 Sansom St.
San Francisco, 523 Market St.

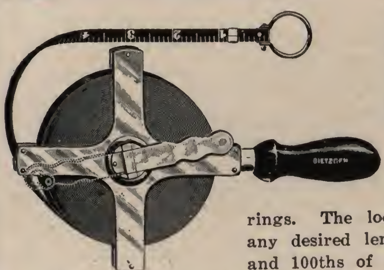
Washington, 407 Tenth St. N. W.
Los Angeles, 840 So. Hill St.
Milwaukee, 379 Broadway.

Products: STEEL TAPES, LEVELS, TRANSITS, LEVELING RODS, DRAFTING SUPPLIES.

DIETZGEN TRADE MARK ESTABLISHED 1885

Monarch Steel Tape has a heavy black finished ¼ in. steel ribbon, simplified reading, designed for heavy yet precise work. Of an engineers pattern divided into 10ths and 100ths of a foot. In strong steel lined hand sewed leather case with long leverage handle opens by press button. Tape detachable from case, furnished with two detachable end rings.

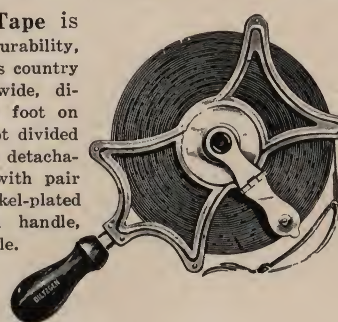
No. 5000F 100 ft. List Price $15.60



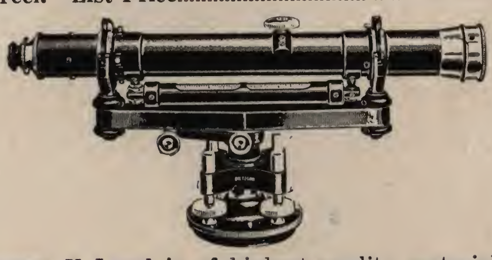
Angus Steel Tape has lock handle, steel frame, heavy black finished ¼ in. steel ribbon; simplified reading; designed for all engineering work; line is easily removed from the frame; furnished with two detachable end rings. The lock handle locks tape at any desired length. Divided into 10ths and 100ths of a foot and has a strong steel frame with polished hard wood handle. Nickel-plated mountings.

No. 5100F, 100-ft. List Price....................$13.50

Indestructible Steel Tape is of almost indestructible durability, designed for rough or cross country work. Steel ribbon $\frac{5}{16}$″ wide, divided and numbered every foot on babbitt metal, each end foot divided into 10ths of a foot. Tape detachable from reel, furnished with pair of rawhide thongs. Nickel-plated steel reel with hardwood handle, long folding winding handle.



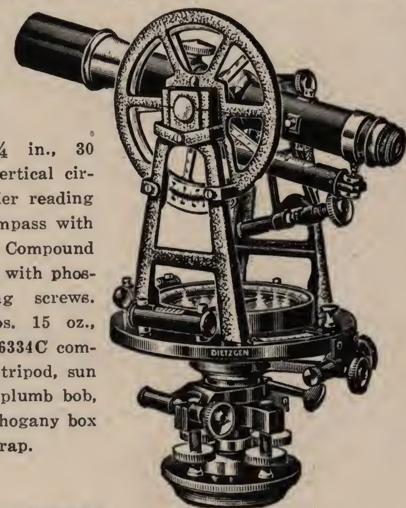
No. 5530, 100 ft. without reel. List Price $6.00
No. 5531, 100 ft. with reel. List Price....................$9.00



Engineers Y Level is of highest quality material and workmanship. Telescope 18″; Objective 1⅜″; Mag. power 30 to 35 dia.; Erecting eye piece; improved focusing sleeve gives clear flat field of vision. Telescope level 7¾″; 20 sec. sensibility. Hard bell metal long tapered center in phosphor bronze socket—accurate and stable. Ribbed bronze leveling base with nickel silver leveling screws. Weight 11 lbs. 5 oz., Tripod 10 lbs. Complete with tripod, sun shade, adjusting pins, in mahogany box with lock, key and strap.

No. 6008. Price List....................$200.00

Dietzgen Transits. Built with accuracy and stability for engineering and highway work. Horizontal circle 5¼ in., graduated on sterling silver with two rows of figures, reading 0 to 360° both ways, double verniers; **Two plate** levels. Telescope 9½ in. long; magnifying power 18 to 20 dia., 1¼ in. objective; Erecting eye piece; telescope level 5¼ in., 30 seconds sensibility; vertical circle 4¼ in. dia., vernier reading to 1 min.; 3¾ in. compass with variation plate. Compound centers; leveling base with phosphor bronze leveling screws. Weight about 11 lbs. 15 oz., Tripod 8¾ lbs. No. 6334C complete, with extension tripod, sun shade, adjusting pin plumb bob, magnifying glass, mahogany box with lock, key and strap.



No. 6334C

6334C. List Price..$290.00

Dietzgen Leveling Rods. Dietzgen rods are made of selected, well seasoned, straight grained maple graduated on white enamel to 10ths and 100ths.

No. 6500 Philadelphia Rod. Oval target, vernier reading to 1,000 of a ft.; two sliding sections reading to 7.0 feet closed, sliding out to 13 feet.

List Price..........$16.50

No. 6510 Philadelphia Rod without target, two sliding sections reading to 7.3 feet closed, sliding out to 13.8 feet.

List Price..........$8.50

No. 6514 like No. 6510 but reading to 6.0 closed, sliding out to 11.2 feet.

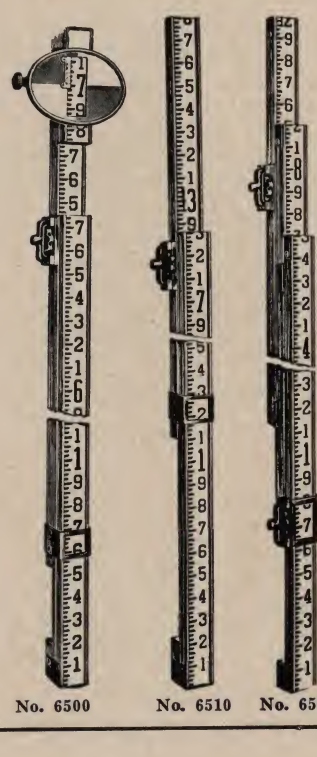
List Price..........$8.00

No. 6520 California Rod, three sliding sections reading to 4.5 feet closed, sliding out to 12 feet.

List Price..........$17.50

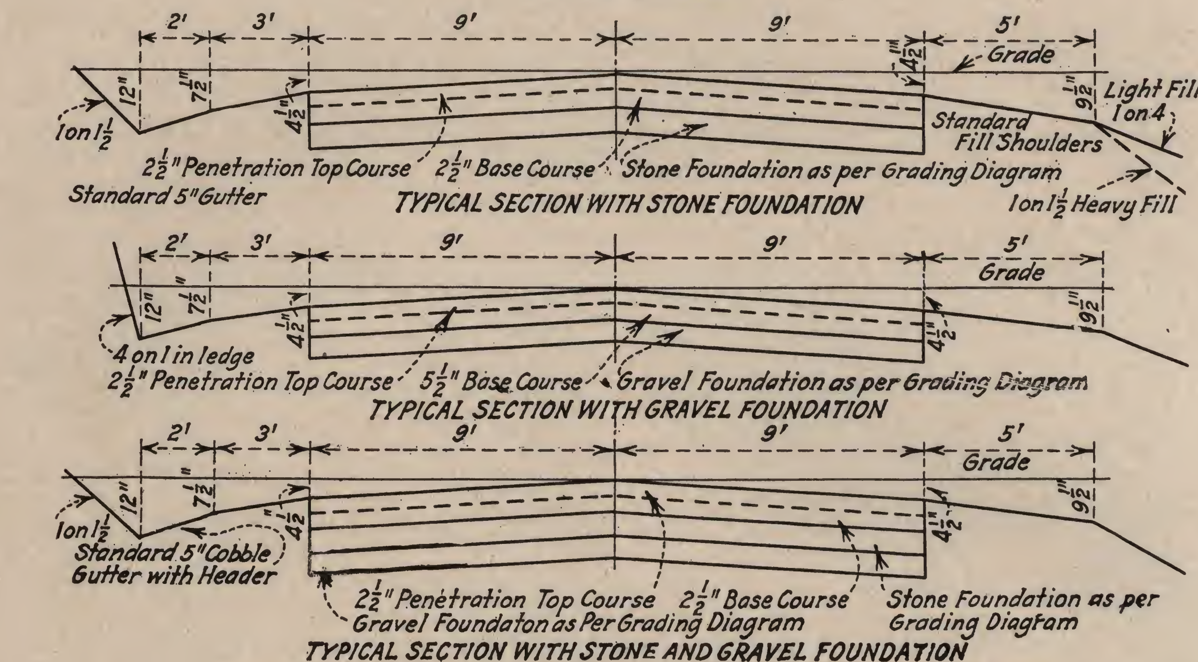
No. 6522 like No. 6520 reading to 5.5 feet closed, sliding out 15 feet.

List Price..........$20.50

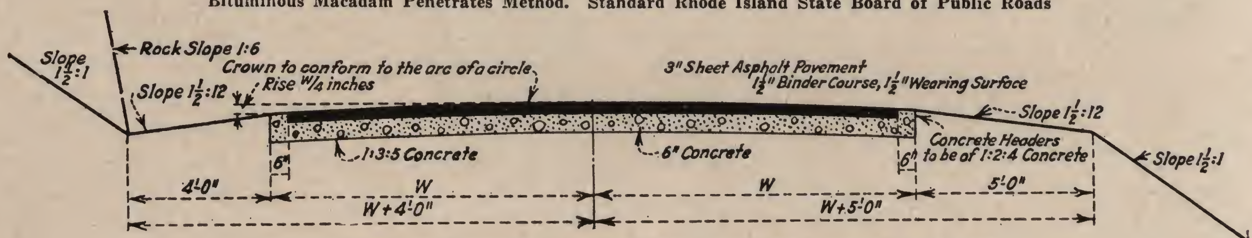


No. 6500 No. 6510 No. 6520

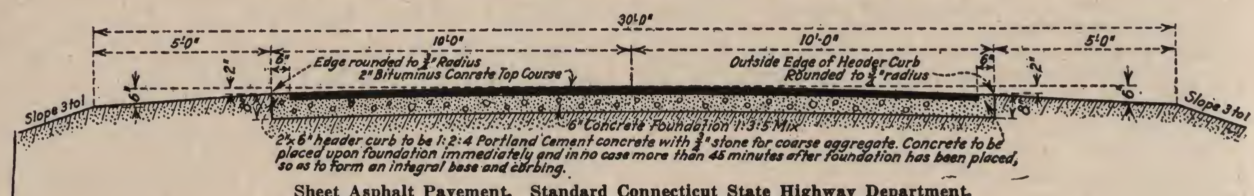
Bituminous Pavements



Bituminous Macadam Penetrates Method. Standard Rhode Island State Board of Public Roads



Bituminous Concrete, One Course. Standard New Jersey State Highway Department



Sheet Asphalt Pavement. Standard Connecticut State Highway Department.

APPROXIMATE QUANTITIES OF MATERIALS REQUIRED FOR ASPHALT WEARING COURSES AND FOUNDATIONS

From Pocket Reference for Engineers of The Asphalt Association

Sheet Asphalt

Binder 1½ In. Thick, Wearing Course 1½ In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile 1 Ft. Wide
Binder Stone	116	34.0
Sand:—		
Top	115	33.8
Binder	45	13.2
Mineral Filler	22	6.5
Asphalt:—		
Top	16	4.7
Binder	9	2.6

Asphalt Macadam Base

6 In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile 1 Ft. Wide
Coarse Stone	545	159.8
Intermediate Stone (Optional)	45	13.2
Asphalt	22	6.5

Asphaltic Concrete Base

3 In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile 1 Ft. Wide
Coarse Stone	216	63.4
Sand	100	29.3
Asphalt	18	5.3

Asphalt Macadam Wearing Course

2½ In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile 1 Ft. Wide
Coarse Stone	227	66.6
Intermediate Stone	45	13.2
Fine Stone	25	7.3
Asphalt	19	5.6

Fine Graded Aggregate Asphaltic Concrete

2 In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile 1 Ft. Wide
Stone Chips	53	15.5
Sand	123	36.1
Mineral Filler	18	5.3
Asphalt	18	5.3

Coarse Graded Aggregate Asphaltic Concrete
2 In. Thick, Excluding Seal Coat

Materials	Pounds Per Sq. Yd.	Tons Per Mile 1 Ft. Wide
Coarse Stone	147	43.1
Sand	58	17.0
Mineral Filler	9	2.6
Seal Coat Stone	25	7.3
Asphalt	18	5.3

Amounts of Materials for Penetration Bituminous Macadam.—Wilson G. Harger in his "Rural Highway Pavements," gives the following:

"For penetration top course our records in western New York show that the proportion of sizes per cubic yard of finished top (limestone aggregate) are approximately as follows:

	Per cent
1½ to 2½ in. size crushed stone	65
¾ to 1½ in. size	20
Dustless screenings	15

The total weight of all sizes limestone specific gravity 2.7 (170 lb. per cubic foot solid) is about 4,250 lb. per cubic yard for a 2½ in. consolidated depth of finished macadam and about 4,350 lb. per cubic yard for a 3 in. consolidated depth.

The following table is from the Asphalt Association:

ASPHALTIC MACADAM WEARING COURSE
(2½ in. Consolidated Thickness)

Materials	Lbs. per sq. yd.
Coarse stone	227
Intermediate stone	45
Screenings	25
Asphalt	19
Total	316

For single coat work on steep grades, 1.5 gal. per square yard applied in one coat is satisfactory for 2½ in. depth of top and 1.75 gal. per square yard for the 3 in. depth. When seal coats are used on the lighter grades 0.4 to 0.5 gal. is generally used.

Weights of Asphalt Paving and Road Material.—Asphalt of a specific gravity of 1.0 or unity weighs 8.33 lb. to the gallon or 62.5 lb. to the cubic foot. The following table from a hand book of the Asphalt Association shows the weight in pounds per gallon for various specific gravities:

Sp. Gr.	Weight	Sp. Gr.	Weight
1.00	8.33	1.04	8.66
1.01	8.41	1.05	8.75
1.02	8.50		
1.03	8.58	1.06	8.83

A handbook of the Standard Oil Company of Indiana gives the following:

Paving asphalt weighs 8.5 lb. to the gallon, approximately 235 gal. to the ton at 60° F.

One cu. ft. of paving asphalt weighs 64 to 65 lb.

One ton of paving asphalt contains approximately 30 cu. ft.

One drum of paving asphalt contains 48 to 50 gal.

One drum of asphalt weighs approximately 440 lb.

The weight of standard sheet asphalt 2 in. thick, rolled and compressed on a uniform close binder, is 200 lb. to the square yard.

The weight of close binder 1½ in. thick, rolled and compressed on uniform concrete base, is 130 to 140 lb. to the sq. yd.

The weight of asphaltic concrete 2 in. thick, rolled and compressed on uniform concrete base, is 200 to 210 lb. to the sq. yd.

The weight of asphalt macadam 2½ in. thick, rolled and compacted, is 250 to 260 lb. to the sq. yd.

Bituminous Surface Treatment

Specifications Massachusetts Division of Highways.

Description: After the road has been surfaced with gravel or with waterbound macadam, a bituminous surface treatment shall be applied (if required under "Special Provisions") in accordance with these specifications.

Materials: The bituminous material shall consist of tar or asphaltic oil; the kind to be used and the number of gallons to be applied per square yard will be given under "Special Provisions."

The tar shall be homogeneous and shall meet the following requirements:

1. Water content.....not more than 2 per cent
2. Specific viscosity at 40° C. (104° F.).....8 to 17
3. Total distillate by weight:
   0° C. to 170° C. (338° F.).....not more than 7 per cent
   0° C. to 270° C. (518° F.).....not more than 37 per cent
   0° C. to 300° C. (572° F.).....not more than 45 per cent
4. Melting point of residue.....not more than 60° C.
5. Total bitumen (soluble in carbon disulphide).....not less than 88 per cent

Asphaltic oil shall be homogeneous and free from water.

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.).....0.92 to 0.970
2. Flash point.....not less than 50° C. (122° F)
3. Specific viscosity at 25° C. (77° F.).....30 to 65
4. Loss at 163° C. (325° F.) 5 hours.....not more than 30%
5. Total Bitumen soluble in carbon disulphide.....not less than 99.5%
6. Total Bitumen insoluble in 86° B naptha.....not less than 6.0%
7. The asphaltic content at 100 penetration.....shall be between 45% to 55%

The sand shall consist of grains or particles of quartz or other hard and durable rocks. The grains shall be sharp, free from loam and clay or other foreign materials.

Construction Methods: The surface to be treated shall be swept of all loose material with brooms or a horse sweeper approved by the Engineer. If directed by the Engineer the surface shall then be watered slightly. Upon the surface for the full width two (2) applications of bituminous material herein before described shall be applied cold in a thin film, distributed evenly by means of a pressure machine approved by the Engineer, so designed as to enable its operator to control the flow and to distribute the material uniformly under a pressure of not less than thirty (30) pounds per square inch, leaving no streaks or spots and so designed as to enable its operator to "cut out" any portion of the roadway and to avoid any surplus deposit of the material on the roadway or elsewhere. If the Engineer shall so direct the bituminous material shall also be further distributed by means of soft brooms or squeegees.

As soon as possible after each application of bituminous material as hereinbefore specified, a thin layer of sand shall be distributed evenly thereon in sufficient quantity to absorb all surplus bituminous material and form a true surface.

No bituminous work shall be done during rainy weather nor when weather conditions as to temperature or otherwise are in the opinion of the Engineer unfavorable for obtaining satisfactory results.

All unsatisfactory material shall be removed and replaced by and at the expense of the Contractor.

Bituminous Macadam Surface Course

Specifications Massachusetts Division of Highways

Description: The bituminous macadam surface shall be laid on a "Broken Stone Base Course."

The surface course shall be composed of broken stone and bituminous material applied by the penetration method with the bituminous material covered with pea stone.

The width and depth (after rolling) of the bituminous macadam surface course shall be as shown on the plans.

Materials: The broken stone for the surface course shall consist of clean crushed rock having a French coefficient of wear of not less than fourteen (14) and a toughness of not less than twelve (12) unless otherwise specified in the Special Provisions. The stone shall be thoroughly screened, uniformly graded in size and quality, angular and free from rounded surfaces, and no flat, elongated or otherwise objectionable stone shall be used.

The stone used shall consist of No. 1 stone, excepting that pea stone shall be used for covering the bituminous material.

Pea stone shall consist of that portion of the crusher product which will pass a three-quarter (¾) inch screen and will be retained on a one-quarter (¼) inch screen, and it shall be free from dust.

The bituminous material shall consist of asphalt or refined tar, as specified under "Special Provisions."

Oil asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Oil asphalt applied from June 1 to August 31 inclusive shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.).....Not less than 1.000
2. Flash point.....not less than 175° C. (347° F.)
3. Melting point.....37° C. (99° F.) to 57° C. (135° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec.....85 to 100
5. Loss at 163° C. (325° F.), 5 hours.....not more than 1.0%
   (a.) Penetration of residue at 25° C. (77° F.), 100 g., 5 sec.....not less than 55

6. Total bitumen (soluble in carbon disulphide)....not less than 99.5%
   Organic matter insoluble....not more than 0.2%

Oil asphalt applied from September 1 to May 31, inclusive, shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)....not less than 1.000
2. Flash point....not less than 175° C. (347° F.)
3. Melting point....35° C. (95° F.) to 55° C. (131° F.)
4. Penetration at 25°C. (77° F.), 100 g., 5 sec....100 to 120
5. Loss at 163° C. (325° F.), 5 hours....not more than 1.0%
   (a) Penetration of residue at 25° C. (77° F.), 100 g., 5 sec.....not less than 60
6. Total bitumen (soluble in carbon disulphide)....not less than 99.5%
   Organic matter insoluble....not more than 0.2%

Fluxed native lake asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)....1.025 to 1.050
2. Flash point....not less than 175° C. (347° F.)
3. Melting point....35° C. (95° F.) to 45° C. (113° F.)
4. Penetration at 25° C. (77° F.), 100 g., 5 sec....120 to 150
5. Loss at 163° C. (325° F.), 5 hours....not more than 3.0%
   (a) Penetration of residue at 25° C. (77° F.), 100 g., 5 sec.....not less than 60
6. Total bitumen (soluble in carbon disulphide)....not less than 95.0%
   Inorganic matter insoluble....1.5% to 2.5%

Refined tar shall be homogeneous and free from water. It shall meet the following requirements:

1. Specific gravity 25°/25° C. (77°/77° F.)....not less than 1.000
1. Float test at 50° C....160 sec. to 220 sec.
2. Total distillate by weight:
   0° C. to 170° C....not more than 1.00%
   0° C. to 270° C....not more than 10.00%
   0° C. to 300° C....not more than 20.00%
   (a) melting point of residue....not more than 70° C.
3. Total bitumen (soluble in carbon disulphide)....78% to 97%

Construction Methods: Upon the broken stone base course shall be spread a surfacing course of No. 1 stone. Before the surfacing course is spread, shoulders shall be relined and graded to hold stone in place and to permit the roller to lap at least one-half the width of a rear wheel when rolling the edge of the top course.

All broken stone shall be spread from vehicles by hand, or from a dumping board, or from self-spreading vehicles which shall be of a type approved by the Engineer. If dumped on the base course in piles, it must not be deposited within the area over which it is to be spread. The course shall be shaped to a true section conforming to the proposed cross-section of the highway, and when thoroughly rolled, shall conform to the proposed grade and cross-section. Any depressions or irregularities which may occur shall be filled with broken stone, of such sizes as directed by the Engineer, and again rolled until the surface is true and unyielding. Before rolling, the wheels of the roller shall be cleaned and precautions taken to prevent the depositing of dirt or other material in the voids of the broken stone. The rolling shall then proceed as for the base course, care being taken in rolling the edges to overlap the shoulders by at least one-half the width of a rear wheel. Before any bituminous material is applied, all foreign substances and any unsuitable broken stone or broken stone which has become coated or mixed with dirt or foreign substances, shall be removed and replaced with clean No. 1 stone. The stone shall be perfectly dry before the bituminous material is applied.

Upon the upper course of stone prepared as above, the bituminous material shall be uniformly applied by an approved pressure distributor at the rate of two and one-quarter (2¼) gallons to each square yard of surface. The surface shall then be covered with sufficient clean pea stone to keep the bituminous material from sticking to the wheels, care being taken that the rolling starts while the surface is still warm. The pea stone shall be added in small amounts while the rolling continues. Brooms shall be used in distributing the pea stone, and only a quantity sufficient for filling the voids shall be spread, and any excess shall be avoided. Before the rolling proceeds, any surplus bituminous material on the shoulders shall be removed in order to permit rolling the shoulders in conjunction with the surface. Immediately before the seal coat is applied, the surface shall be thoroughly swept to remove all loose material and dust. The seal coat shall then be evenly applied in the same manner as the penetration coat and at the rate of one-half (½) gallon per square yard and immediately covered with pea stone.

Bituminous material when applied to the upper course of stone shall have a temperature of not less than 300° F. and not more than 350° F. for asphalt, and not less than 200° F. and not more than 275° F. for tar. The Contractor shall not allow the bituminous material to be overheated or burnt.

After the seal coat is applied, any surplus bituminous material on the shoulders shall be removed, in order to permit rolling of same with the finished surface.

When spraying bituminous material, the Contractor shall cover concrete walks, curbs and walls along the roadway with paper or other covering satisfactory to the Engineer. No additional compensation will be allowed the Contractor for this work. If any bitumen should strike concrete walks, curbs and walls, it shall be removed by the Contractor at his own expense.

Any depressions or irregularities appearing after the final rolling shall be neatly patched in such a manner as shall be directed by the Engineer, so that the final surface will be perfectly uniform and true to the specified cross-section and grade.

If at any time before the acceptance of the work any soft or imperfect places or spots shall develop in the surface, all such places shall be removed and replaced with new material and then rolled until thoroughly compacted and until the joints or edges at which the new work connects with the old become invisible. All such removal and replacing and unsatisfactory surfacing shall be done at the expense of the Contractor.

Bituminous Concrete Pavement (Modified Topeka)

Specifications Ohio State Department of Highways.

Description: This item shall consist of a wearing course composed of a compacted mixture of mineral aggregate and bituminous material, and shall be constructed on the completed and accepted base course or in the case of a bridge on the prepared floor or approach slab in accordance with these specifications and in conformity with the lines, grades, compacted thickness and typical cross sections shown on the plans.

Asphalt Cement: The asphalt cement to be used in this course shall meet the requirements as specified under Section 5.2* of the "Material Details." The penetration of the asphalt cement may be varied by the Director within the limits specified to adapt it to the particular kind of asphalt used and to the traffic and other conditions. Before placing shipping orders for the asphalt cement the Contractor shall obtain instructions from the Director as to the penetration required. It shall have the required penetration when shipped from the refinery. Fluxing of the asphalt on the work will not be permitted.

Sand: The sand to be used in the mixture shall meet the requirements as specified under Section 2.7** of the "Material Details."

Coarse Aggregate: Unless otherwise shown on the plans or in the approximate estimate, the stone to be used in this course shall meet the requirements as specified under Section 3.1, 3.5 or 3.6† of the "Material Details," and shall be clean and free from dust and of such size that all will pass a three-quarter (¾) inch screen.

Stone Dust: The stone dust to be used shall be free from clay or loam, and shall be ground to such fineness that not less than seventy (70%) per cent shall pass a No. 200 sieve, and all pass a No. 80 sieve and be dry when used.

Proportions: The bituminous concrete as laid shall comply with the following requirements for percentage composition.

Bitumen	7 to 9%
Filler passing a No. 200 sieve	8 to 15%
Mineral aggregate passing a No. 80 and retained on a No. 200 sieve	10 to 20%
Mineral aggregate passing a No. 40 and retained on a No. 80 sieve	15 to 35%
Mineral aggregate passing a No. 10 and retained on a No. 40 sieve	10 to 25%
Mineral aggregate passing a ¼-inch screen and retained on a No. 10 sieve	15 to 30%
Mineral aggregate passing a ¾-inch screen and retained on a ¼-inch screen	5 to 15%

The per cent of bitumen and filler shall be varied within the limits designated at the order of the Director. The item designated as "Filler" within the limits named herein includes in addition to the stone dust, fine sand passing a No. 200 sieve, not exceeding 4 per cent of the entire mixture, and mineral dust naturally contained in the refined asphalt. The required percentages of asphalt cement, stone, and sand shall be measured at all times by actual weighing with suitable scales. The stone dust must also be weighed unless an approved method of gauging is used.

Mixing: The stone and sand shall be heated before entering the mixer to between 250 degrees F. and 350 degrees F. in revolving dryers of an approved type. The stone and sand shall be continuously agitated during the heating. The asphalt shall be heated in kettles or other suitable appliances, so designed as to admit of even heating of the entire mass with an efficient and positive control of the heat at all times. It shall be heated as directed to a temperature between 275 degrees F. and 350 degrees F. All asphalt cement heated beyond 350 degrees F., either before or during mixing with the broken stone and sand, shall be rejected. Asphalt cement in the required proportion shall be added and the aggregate and the mixing continued in a suitable mixer until a homogeneous mixture is produced, in which all the particles are coated uniformly. When discharged the mixture shall have a temperature of not less than 250 degrees F., nor more than 350 degrees F.

Delivering of Bituminous Concrete: The bituminous concrete shall be hauled to the work in tight vehicles previously cleaned of all foreign materials and covered with canvas of sufficient size to protect the entire load. The dispatching of the vehicles shall be arranged so that all materials delivered may be placed and shall have received initial rolling in daylight.

Placing: The bituminous concrete shall be laid only on a base course which is dry and free from loose or foreign materials and only when weather conditions are suitable. Contact surfaces of curbs, structures and all joints shall be painted with a thin uniform coating of asphalt cement before the bituminous concrete is spread. The mixture shall have a temperature of at least 225 degrees F. when laid. The bituminous concrete shall be dumped outside of the area on which it is to be spread, the entire load distributed into place and raked to grade in a uniformly loose layer of such depth that after receiving ultimate compression by rolling the finished pavement shall conform to the required grade and cross-section. Adjacent to flush curbs, headers, gutters, liners and structures the

surface mixture shall be raked uniformly high so that when rolled it shall be slightly above the edge of curb, gutter, etc.

Rolling: As soon as practicable after placing, the mixture shall be thoroughly and uniformly compressed by means of rolling with an eight (8) or ten (10) ton tandem roller. The roller shall give a compression of approximately 250 pounds per inch width of tread. The roller shall be operated both longitudinally and diagonally across the pavement until the mixture is thoroughly compacted and the surface is smooth and even and conforms to the required grade and cross-section. Rolling shall continue until all roller marks are removed from the surface and at least 96% of the theoretical density is obtained. For a radial distance of eight (8) inches around all structures, adjacent to curbs, gutters and all other locations inaccessible to the roller, the compression shall be effected by hot iron tampers weighing not less than 25 pounds and having a bearing area not exceeding 48 square inches.

For the purpose of testing the finished surface, a ten (10) foot straight edge and a templet cut to the cross section of the road shall at all times be available on the work. The finished pavement shall be such that it will vary at no place more than three-eighths (⅜) of an inch from a template cut to the cross section of the road, nor from a ten (10) foot straight edge applied parallel to the center line of the pavement. Any irregularity of the surface, exceeding three-eighths (⅜) of an inch shall be corrected before the final estimate will be paid.

Depressions which may develop after the initial rolling shall be remedied by loosening the surface mixture laid and adding new material to bring such depressions to a true surface. Such portions of the pavement, after the final rolling, as are defective in surface, compression, or composition, or that do not comply with the requirements of the specifications shall be taken up, removed and replaced with suitable material properly laid in accordance with these specifications.

Joints in Surface Course: Placing of the surface course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is to be discontinued for such length of time as to permit the mixture to become chilled. In all such cases and in the formation of joints, provision shall be made for proper bond with new surface mixture by cutting or trimming back the joint while the material is still hot, so as to expose an unsealed or granular surface for the full specified depth of the course. When the laying of the surface mixture is resumed, the exposed edge of the joint shall be painted with a thin coat of hot asphalt cement, or asphalt cut back with naphtha, and the fresh mixture shall be raked against the joint, thoroughly tamped with hot tampers and rolled. Hot smoothing irons may be used for sealing joints, but in such case extreme care shall be exercised to avoid burning the surface.

Protection of Surface Course: After the completion of the wearing course no vehicular traffic of any kind shall be permitted on the pavement until it shall have hardened sufficiently and in no case less than six (6) hours after placing the bituminous concrete.

Special. The Contractor shall provide and maintain at the plants a sufficient number of accurate, efficient stationary and portable thermometers, and other apparatus necessary for the determination of temperatures, penetrations, quantities of materials used and grading of the mineral aggregates. The plant used in preparing the bituminous mixture shall be equipped with an electric pyrometer or other approved thermometric instrument so placed at the discharge chute of the dryer as to automatically register the temperature of the heated aggregates. The Contractor shall also provide a suitable field laboratory in which to house and use the equipment necessary to carry on the required tests, this laboratory to be used exclusively for testing purposes by the contractor, engineer or inspector.

***Sec. 5.2—Bituminous Material A-2.**

(Mixing Method)

Bituminous Material A-2 shall be homogenous, free from water and shall not foam when heated to 177° C. (350° F.).

Unless otherwise shown on the plans or in the estimate A-2 (a) and A-2 (b) are optional.

	A-2 (a)	A-2 (b)
(1) Specific gravity 25° C./25° C. not less than	1.01	1.05†
(2) Flash point, not less than	175° C.	175° C.
(3) Penetration at 25° C. 100 g.-5 sec.	40 to 60	40 to 60
(4) Ductility at 25° C. (at 50 Pen.)* not less than	50 cm.	30 cm.
(5) Loss at 163° C.—5 hours, not over	1%	3%
(6) Penetration of residue at 25° C., not less than % of original	60%	60%
(7) Total bitumen (sol. in CS_2) not less than	99.5%	94%‡
(8) Fixed Carbon	10 to 19%	9 to 14%
(9) Per cent of total bitumen insoluble in 86° B. naptha	20 to 32%	19 to 28%
(10) Per cent of total bitumen insoluble in carbon tetrachloride, not over	1.0%	1.0%

†1.20 for fluxed Trinidad.

*Variation from 50 Penetration 2 cm. for each 5° Penetration.

‡Note—(65% to 75%) for Trinidad A. C.

†Sec. 2.7—Sand B. C.

(Bituminous Concrete)

The sand shall be composed of clean, hard, durable uncoated particles of stone, free from clay and organic matter.

Grading:

Passing ¼-in. screen	100%
Passing No. 10 sieve, retained on No. 40 sieve	12-40%
Passing No. 40 sieve, retained on No. 80 sieve	25-60%
Passing No. 80 sieve, retained on No. 200 sieve	20-45%
Passing No. 200 sieve, not over	6%

***†Sec. 3. 1—Limestone Grade A.**

Limestone of this grade shall meet the following requirements:

General.

The broken stone shall be clean, sound, durable, angular, of uniform quality, and free from thin, flat or shaley pieces.

Physical Properties.

Per cent of wear	not over 6.0%
Hardness	not less than 14.0
Toughness	not less than 5.0

The stone shall show no signs of checking, cracking, or disintegrating in the sodium sulphate solution test for soundness.

Sec. 3. 5—Crushed Rock—Special.

May include crushed boulders composed of limestone, granite, trap rock or rock of a similar nature and shall meet the following requirements:

General.

The broken stone shall be clean, sound, of uniform quality, and free from thin or elongated pieces. If produced by crushing gravel only that portion which has been retained upon a screen with 3½ inch or larger openings shall be used.

Physical Properties.

Per cent of wear	not over 5.0%
Hardness	not less than 15.0
Toughness	not less than 6.0

****Sec. 3.6—Slag Grade A.**

Slag of this grade shall meet the following requirements:

General.

The broken slag shall be clean, sound, durable, reasonably uniform in density and free from thin or elongated pieces.

Physical Properties.

Per cent of wear (stone test)	not over 15%
or, Per cent of wear (gravel test)	not over 20%
Weight per cu. ft. (as aggregate-compacted)	not less than 70 lbs.

The slag shall show no signs of checking, cracking, or disintegration in the sodium sulphate solution test for soundness.

Bituminous Concrete Pavement (Coarse Mix)

Specifications Ohio State Department of Highways.

Description: This item shall consist of a wearing course composed of a compacted mixture of mineral aggregate and bituminous material, and a seal coat, and shall be constructed on the completed and accepted base course in accordance with these specifications and in conformity with the lines, grades and typical cross-section shown on the plans.

The mineral aggregate shall consist of coarse aggregate, fine aggregate, and mineral filler.

The seal coat shall be of a "Flush" or "Squeegee" coat applied hot and a mineral cover.

Asphalt Cement: The asphalt cement to be used in this course shall meet the requirements as specified under "Material Details," except that the penetration shall be fifty to sixty. Fluxing of the asphalt on the work will not be permitted.

Sand: The sand to be used in the mixer shall meet the requirements as specified under Section 2.7* of the "Material Details."

Coarse Aggregate: Unless otherwise shown on the plans or in the special provisions and proposal the stone to be used in this course shall meet the requirements as specified under Section 3.1, 3.5 or 3.6* of the "Material Details," and shall be clean and free from dust.

Stone Dust: The stone dust to be used shall be free from clay or loam, and shall be ground to such fineness that not less than seventy (70%) per cent shall pass a No. 200 sieve, and all pass a No. 80 sieve and be dry when used.

Seal Cover Material: The covering material shall meet the requirements as specified under Section 3.5 or 3.9 and shall be No. 6 size.

Proportions: The bituminous concrete as laid shall comply with the following requirements for percentage composition:

Passing a 1¼-in. screen and retained on a ½-in. screen	40 to 60%
Passing a ½-in. screen and retained on a ¼-in. screen	10 to 20%
Passing a ¼-in. screen and retained on a No. 10 sieve	5 to 15%
Passing a No. 10 sieve	25 to 35%
Bitumen	5 to 7%

The portion of the aggregate passing a 10-mesh sieve when considered separately from the remainder of the aggregate shall meet the following screen test:

*See foot notes for specification for bituminous concrete pavement (Modified Topeka).

Passing a 10 mesh and retained on a 40 mesh sieve	15 to 40%
Passing a 40 mesh and retained on an 80 mesh sieve	22 to 53%
Passing an 80 mesh and retained on a 200 mesh sieve	15 to 40%
Passing a 200 mesh sieve	10 to 15%

Preparation and Mixing: The ingredients shall be heated to such a temperature between the limits of 250 and 350 degrees F. that when the mixture is delivered on the work, it shall be in a sufficiently plastic condition for spreading and rolling (which will vary with the temperature of the air). The aggregate shall not be heated to a sufficiently high temperature to injure the asphalt cement. The following method of proportioning and mixing shall be used:

The mineral aggregate shall be thoroughly dried and heated in a rotary drier, and while still hot, shall be separated into at least four sizes by means of a rotary screen so arranged that the product of each screen section shall drop into a corresponding compartment or bin. The aggregate capacity of all the compartments to be not less than ten (10) cubic yards. From these several compartments, the desired amount of each size aggregate shall be drawn into a weigh box resting on a multi-beam scale, and each size shall be weighed accurately and separately therein, after which the whole batch shall be emptied into a "Twinpug" mixer, where it shall be thoroughly mixed with the separately heated asphaltic cement, until the combination is a uniform bituminous concrete.

Delivery of Surface Mixture: The surface mixture shall be hauled to the work in tight vehicles previously cleaned of all foreign materials and covered with convas of sufficient size to protect the entire load. Dispatching of the vehicles shall be arranged so that all materials delivered may be placed and shall have received initial compression in daylight.

Placing Surface: If at the time of laying surface course mixtures permanent side supports such as curbs, edgings, or gutters have not been constructed, planks of suitable thickness shall be laid along each side of the pavement and rigidly supported so as to prevent the mixture from being displaced under the roller. These planks shall remain in place until final compaction has been obtained. Prior to the arrival of the surface mixture on the work, the base course shall have been cleaned of all loose and foreign materials. The surface mixture shall be laid only on a base course which is dry and only when the weather conditions are suitable. Contact surfaces of curbings and gutters, and all joints shall be painted with a thin, uniform coating of asphaltic cement before the surface mixture is spread. Upon arrival on the work the surface mixture shall be dumped outside of the area on which it is to be spread, the entire load distributed into place and spread by suitable means in a uniformly loose layer of such depth that after rolling it shall have a compacted depth as shown on the plans. Shovellers will not be permitted to stand in the hot material, and rakers may tread the loose material only where necessary to correct errors in the first raking. The surface mixture shall be at a temperature of at least two hundred and twenty-five (225) degrees F. when laid. Adjacent to flush curbings, gutters, liners, and structures, the surface mixture shall be spread uniformly high so that when completed it will be slightly above the edge of the curbing, gutters, etc.

Rolling: Initial compression of the surface mixture shall be effected with an approved power roller, weighing approximately ten (10) tons. Rolling shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least one-half (½) of the width of the roller, and shall continue until all roller marks are removed from the surface and at least 96 per cent of the theoretical density is obtained. The roller shall be operated longitudinally and diagonally across the pavement until the surface is smooth and even and parallel to the grade and cross-section given. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture and any displacements occurring as a result of reversing the direction of the roller, or from any cause, shall be corrected by the use of rakes and of fresh material when required. For a radial distance of eight (8) inches around all structures, adjacent to curbings, gutters and railway track liners, and at all other locations inaccessible to the roller, the compression shall be effected with iron tampers weighing not less than twenty-five (25) pounds and having a bearing area not exceeding forty-eight (48) square inches. Care shall be taken at all times to preserve the surface of this material clean and free from dust and all foreign substances. For the purpose of testing the finished surface a ten (10) foot straight edge and a templet, cut to the cross section of the road shall at all times be available on the work. The finished pavement shall be such that it will vary at no place more than three-eighths (⅜) of an inch from a template cut to the cross section of the road, nor from a ten (10) foot straight edge applied parallel to the center line of the pavement, any irregularity of the surface exceeding the three-eighths (⅜) of an inch shall be corrected before the final estimate shall be paid. Ordinates measured from the face of the straight edge to the surface of the pavement shall not exceed 1/16 inch for each foot in distance from the nearer point of contact. All unevenness and depressions shall be remedied in the surface course before the seal coat is applied.

Joints in Surface Course: Placing of the surface course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is to be discontinued for such length of time as to permit the mixture to become chilled. In all such cases and in the formation of joints, provision shall be made for proper bond with new surface mixture by cutting or trimming back the joint while the material is still hot, so as to expose an unsealed or granular surface for the full specified depth of the course. When the laying of the surface mixture is resumed, the exposed edge of the joint shall be painted with a thin coat of hot asphalt cement, or asphalt cut back with naptha, and the fresh mixture shall be raked against the joint, thoroughly tamped with hot tampers and rolled. Hot smoothing irons may be used for sealing joints, but in such case extreme care should be exercised to avoid burning the surface.

Seal Coat. Immediately after initial compression, and while the pavement is still hot, a seal coat of asphaltic cement shall be evenly distributed over the surface by means of an approved distributor or hand pouring pots, and uniformly spread where required, by squeegees.

The hot asphaltic cement shall be applied at a rate of from fifteen hundredths (.15) to three-tenths (.3) gallons per square yard. Upon this seal coat the approved cover material shall be spread immediately in sufficient quantity to cover it uniformly. If necessary this covering shall be heated before being spread. Rolling shall then begin and shall be continued until the resulting wearing surface is compressed thoroughly.

Special: The Contractor shall provide and maintain at the plants a sufficient number of accurate efficient stationary and portable thermometers, and other apparatus necessary for the determination of temperatures, penetrations, quantities of materials used and grading of the mineral aggregates. The plant used in preparing the bituminous mixture shall be equipped with an electric pyrometer or other approved thermometric instrument so placed at the discharge chute of the dryer as to automatically register the temperature of the heated aggregates. The Contractor shall also provide a suitable field laboratory in which to house and use the equipment necessary to carry on the required tests, this laboratory to be used exclusively for testing purposes by the contractor, engineer or inspector.

Sheet Asphalt Pavement

Specifications Connecticut State Highway Department.

Description: This pavement shall consist of an asphaltic concrete binder course, one and one-half (1½) inches in depth when compressed, and a sheet asphalt wearing surface, one and one-half (1½) inches in depth when compressed, constructed on the prepared base course in accordance with these specifications.

Materials: The materials for this pavement shall conform to the following requirements:

(a) **Asphalt** shall be grade NA-1, NA-2 or OA-1, conforming to the requirements as below:

Asphalts may be made from petroleum or from fluxed or unfluxed natural asphalts, and must be free from tar or tar products. They shall be homogeneous, free from water and shall not foam when heated to one hundred seventy-five (175) degrees C. (347 degrees F.). The grades of asphalt required for the different items are given under those items. The asphalt shall conform to one of the following requirements:

PREPARED FROM NATURAL ASPHALTS

Grades	NA-1		NA-2		NA-3	
Tests	Min.	Max.	Min.	Max.	Min.	Max.
Specific Gravity at 25°/25° C. (77°/77° F.)	1.050	1.070	1.200	1.250	1.030	1.070
Penetration at 25° C. (77° F.) 100 grams, 5 seconds	50	60	50	60	85	100
Flash Point, open cup method, in degrees C.	175	....	175	....	175	......
Loss on heating at 163° C. (325° F.) 50 grams, 5 hours		3.0%	......	3.0%	......	3.0%
Penetration of residue at 25° C. (77° F.) 100 grams, 5 seconds, in per cent of original penetration	60%	....	60%	....	60%	......
Ductility at 25° C. (77° F.) in centimeters	30	....	30	....	50	......
Bitumen soluble in carbon disulphide	94.0%	....	68.0%	....	94.0%	......
Bitumen soluble in carbon tetrachloride	99.0%	....	99.0%	....	99.0%	......

PREPARED FROM OIL ASPHALTS

Grades	OA-1		OA-2	
Tests	Min.	Max.	Min.	Max.
Specific Gravity at 25°/25° C. (77°/77° F.)	1.010	....	1.000	......
Penetration at 25° C. (77° F.) 100 grams, 5 seconds	50	60	85	100
Flash Point, open cup method, in degrees C.	175	....	175	......
Loss on heating at 163° C. (325° F.) 50 grams, 5 hours		1.0%	......	1.0%
Penetration of residue at 25° C. (77° F.) 100 grams, 5 seconds in per cent of original penetration	60%	....	60%	......
Ductility at 25° C. (77° F.) in centimeters	50	....	75	......
Bitumen soluble in carbon disulphide	99.5%	....	99.5%	......
Bitumen soluble in carbon tetrachloride	99.0%	....	99.0%	......

(b) **Broken Stone for Binder Course** shall have a Per Cent of Wear of not more than 4.5, a Toughness of not less than 6.0, and shall be ¾ inch stone and screenings combined so as to give the following sieve analysis:

Sieve Tests	Per Cent Min.	Passing Max.
1-inch Screen	95	100
¼-inch Screen	0	25

(c) **Sand for Binder and Top Courses** shall be Bituminous Sand conforming to the requirements as shown below:

Sand shall consist of grains or particles of quartz or other hard, durable rocks, the surfaces of which are not coated with any injurious foreign material. The grains shall be sharp, free from decomposed sand, loam, salt, organic matter or other foreign materials.

Sand shall be classified as "Concrete Sand," "Mortar Sand," "Bituminous Sand" or "Filler Sand," and the class required for any particular item will be stated under that item.

Bituminous sands are those intended for use in sheet asphalt pavements and when tested by means of laboratory screens and sieves, shall conform to the following requirements:

Grades Sieve Tests	Binder Course Min.	Binder Course Max.	Top Course Min.	Top Course Max.
Passing a No. 4 sieve	100%	......	....	....
Passing No. 10, retained on No. 40 sieve	....	......	12%	40%
Passing No. 40, retained on No. 80 sieve	....	......	25%	60%
Passing No. 80, retained on No. 200 sieve	....	......	20%	45%
Passing No. 200 sieve	....	6%	....	6%

(d) **Mineral Filler** shall conform to the following requirements: Mineral filler for use in sheet asphalt pavements or bituminous mastics shall be Portland cement, ground limestone or pulverized lime, conforming to the following requirements:

Passing a 200 mesh sieve..........not less than 65%
Total passing 80 mesh sieve..........not less than 95%
Total passing 30 mesh sieve..........not less than 100%

It shall be free from lumps or balls, or any foreign material which may injure it for the purpose intended.

Asphaltic Concrete Binder Course.—The asphaltic concrete binder course shall be a compacted mass of broken stone, sand and asphalt prepared as follows: The stone and sand shall be heated to a temperature of from two hundred and twenty-five (225) degrees F. to three hundred and twenty-five (325) degrees F., as designated, in approved appliances. The stone and sand shall be measured separately by weight and then mixed with asphaltic cement in such proportions that the resulting mixture, when tested by laboratory screens and sieves, shall meet the following requirements:

	Percentage
Passing a 1-inch screen, retained on a ½-inch screen	15—65
Passing ½-inch screen, retained on Standard No. 10 sieve	20—50
Passing a Standard No. 10 sieve	15—35
Bitumen (soluble in carbon disulphide)	4— 7

Sheet Asphalt Surface Mixture.—The sheet asphalt surface pavement shall consist of a uniform mixture of sand, mineral filler and asphaltic cement. The grading of each constituent shall be such as to produce, when properly proportioned, a mixture conforming to the following limitations of grading. The exact proportions of each constituent, producing the total aggregate within these limits, shall be as directed by the engineer. When tested by means of laboratory sieves, the surface mixture shall meet the following requirements:

	Percentage
Sand Passing a Standard No. 10 sieve, retained on a Standard No. 40	10—32
Sand Passing a Standard No. 40 sieve, retained on a Standard No. 80	20—48
Sand Passing a Standard No. 80 sieve, retained on a Standard No. 200	16—36
Passing a Standard No. 200 sieve	10—18
Bitumen (soluble in carbon disulphide)	9½—12½

The item designated as "Filler" within the designated limits includes, in addition to stone dust or cement, sand passing the Standard No. 200 sieve, not exceeding four and one-half (4½) per centum of the entire mixture and the mineral dust naturally contained in the asphaltic cement.

Preparation of Asphaltic Surface Mixture.—The sand and asphaltic cement shall be heated separately as specified to between two hundred and twenty-five (225) degrees F. and three hundred and twenty-five (325) degrees F. The maximum temperature of the sand as delivered at the mixing box, shall in no case exceed three hundred and fifty (350) degrees F. The maximum temperature of the asphaltic cement shall not exceed two hundred and fifty (250) degrees F. for an oil asphalt and three hundred and fifty (350) degrees F. for a fluxed Bermudez or Trinidad Asphalt. The cold filler shall be mixed thoroughly with hot sand. The asphaltic cement shall then be mixed with the sand and filler at the specified temperature and in the specified proportions until a homogeneous mixture is produced, in which all particles are coated with asphaltic cement. The sand, filler and asphaltic cement for each batch shall be proportioned by weight and shall be weighed separately by scales, attached to the receptacle or bucket used for such proportioning or weighing. The weighing apparatus shall be of approved design, and shall be kept in good working order.

The mixer used shall have revolving blades, and shall be so adapted and operated as to produce and discharge a thoroughly coated and uniform mixture of non-segregated sand, filler and asphaltic cement. When discharged the mixture shall have a temperature of not more than three hundred and twenty-five (325) degrees F., and not less than two hundred and twenty-five (225) degrees F., as directed by the engineer.

Surface of Foundation.—All defective areas in the foundation shall be repaired as directed, in advance of laying the bituminous concrete binder course. Before laying the bituminous concrete the surface of the foundation shall be dry and thoroughly cleaned.

Delivery of Binder.—Asphaltic concrete binder shall be hauled to the work in tight vehicles previously cleaned of all foreign materials and covered with canvas of sufficient size to protect the entire load. The dispatching of the vehicles shall be arranged so that all material delivered may be placed and shall have received initial rolling in daylight. Surface mixture delivered in same manner.

Placing Binder.—Prior to the arrival of the binder on the work, the base course shall have been cleaned of all loose and foreign materials. The binder shall be laid only on a base course which is dry and only when the weather conditions are suitable. It shall be at a temperature of from two hundred (200) to three hundred and twenty-five (325) degrees F., when laid, and shall be spread to a uniform surface and to such depth that after being rolled and compacted thoroughly it shall have a depth of one and one-half (1½) inches and shall be one and one-half (1½) inches below and parallel to the surface of the finished pavement.

Rolling Binder Course.—Compression shall be effected with a tandem power roller of at least eight (8) tons weight. The rolling shall progress continuously at the rate of not more than three hundred (300) square yards an hour. For a radial distance of eight (8) inches around all structures and at all other locations inaccessible to the roller, the compression shall be effected with hot iron tampers, weighing not less than twenty-five (25) pounds and having a bearing area not exceeding forty-eight (48) square inches. To prevent adhesion of the binder material, the roller shall be kept moist. The surface, after compression, shall not show an excess of asphaltic cement, and areas of one (1) square foot or more showing such excess, shall be removed and replaced with new material. Any binder broken up during the process of laying or rolling or remaining unbound after rolling shall be removed and replaced with new material. When deemed necessary, the binder course shall be covered with the surface mixture the same day as laid, and at no time shall there be laid more binder than can be covered by the following run of the plant. All uneveness and depressions shall be remedied in this course before the surface course is laid. No traffic shall be permitted on the binder course, and all binder becoming coated with any foreign material shall be removed and replaced.

Placing Surface Mixture.—The surface mixture shall be laid only on binder which is dry and free from loose or foreign materials and only when weather conditions are suitable. Contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coating of asphaltic cement before the surface course is spread. The surface mixture shall be at a temperature of at least two hundred and fifty (250) to two hundred and eighty (280) degrees F., when laid, depending upon the character of the asphalt used. The surface mixture shall be dumped outside of the area on which it is to be spread, and the entire load distributed into place and raked to grade in a uniformly loose layer of such depth that after receiving ultimate compression by rolling it shall have a depth of one and one-half (1½) inches. Adjacent to flush curbs, gutters, liners and structures the surface mixture shall be raked uniformly high so that when completed it will be slightly above the edge of the curb, gutter, etc.

Rolling Surface Course.—Initial compression shall be effected with a tandem power roller, weighing approximately two and one-half (2½) tons, having a main roll of such width as to give a compression of approximately one hundred and twenty-five (125) pounds per inch width of tread. Final compression shall be effected with a tandem power roller weighing not less than (8) tons having a main roll of such width as to give a compression of approximately two hundred and fifty (250) pounds per inch width of tread. To prevent the adhesion of surface mixture material, the roller shall be kept slightly moist. The rolling shall progress continuously at the rate of not more than two hundred (200) square yards per hour, and shall include, when practicable, complete transverse and longitudinal rollings and two (2) diagonal rollings, approximately at right angles one to the other. For a radial distance of eight (8) inches around all structures, adjacent to curbs, gutters and railway track lines, and at all other locations inaccessible to the roller, the compression shall be effected with hot iron tampers weighing not less than twenty-five (25) pounds and having a bearing area not exceeding forty-eight (48) square inches.

For the purpose of testing the finished surface, a ten (10) foot straight edge shall be available on the work. Depressions which may develop after the first rolling with the two and one-half (2½) ton roller, shall be remedied by loosening the surface mixture laid and adding new material to bring such depressions to a true surface. Should any depressions not be noticeable until the final compression has been made, the surface course and binder shall be removed and sufficient new material laid to form a true and even surface.

Finishing Surface Course.—All projections, joints and honeycombed surfaces shall be ironed smooth to grade, after which Portland Cement shall be swept over the entire surface.

Protection of Surface Course.—After the surface mixture has received its final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it shall have hardened sufficiently and in no case in less than six (6) hours after being placed.

Bituminous Pavement Construction Methods

ASPHALT IN HIGHWAY CONSTRUCTION AND MAINTENANCE.—I. W. Patterson, formerly Chief Engineer, Rhode Island State Board of Public Roads, gave the following in Roads and Streets:

Use of Asphalt in Progressive Plan.—The wide diversity of types of asphalt surfaces makes it possible to carry out a comprehensive plan of progressive development of roads by the use of asphalt, progressing from the cheaper types to the more expensive types. In adopting this plan manifestly it is desirable so to carry out the program that there is a minimum waste in years to come when betterments in surfaces are brought about. Assuming that the initial improvement under a plan of progressive development consist of a gravel road, it is obvious that economy commends the securing of grades and alignments suitable for a more durable surface to be laid in the future. It is equally essential to have the initial gravel road properly drained and substantially constructed, so that there is no appreciable weakness.

For moderate traffic a surface treatment of bitumen over a gravel surface will serve the purpose very well for a number of years, provided proper maintenance is carried out. Perhaps the next step in progressive development would be the laying of a light macadam pavement over the gravel road to serve ultimately as a base for some higher type of pavement. For maintaining the macadam surface also bitumen applied for surface treatment will permit serving traffic very well. It is apparent, of course, that in laying the macadam surface care must be taken to have the cross-section conform approximately to the cross-section of the higher type of pavement to be selected at some future time.

The third step in development might be either an asphalt macadam surface or a bituminous concrete surface laid over the old macadam as a base. It may be on the other hand that one of the higher types of asphalt pavement is considered to be desirable as the second step. In the latter event a substantial gravel road serves admirably as a subgrade for a pavement, and its presence very likely will permit reduction in the depth of pavement which would be required otherwise.

It is seen readily that there is little waste in a progressive plan of development designed to employ asphalt surfaces in the manner described. The secret of success in this plan appears to be in carrying out each step of the procedure with careful consideration of the next step so that nothing need be thrown away. The bitumen applied as surface treatment to be sure is lost, but the cost of the surface treatment annually may be less than the interest on the investment for one of the most expensive types of pavement. If that is the case, there appears to be no economic loss.

Bituminous Surface Treatment of Gravel and Macadam.—The use of bitumens for surface treatment of gravel and macadam surfaces was one of the first steps undertaken to enable roads of that type to withstand motor vehicle traffic. Surface treatment of these surfaces with bitumen at present is widespread. Although for heavy travel, surface treated roads are not considered to be practicable, the method is looked upon with favor for roads carrying moderate travel, especially by way of preservation of old roads. Provided there is no serious foundation trouble so that the surface is not destroyed annually by frost action, a properly built gravel road or a properly built macadam road, when surface treated, will stand up under a considerable volume of travel. Some deplore the plan of salvaging old roads by surface treatment because of the expense of maintenance by this method. In many cases, however, it will be found that adequate service may be rendered by adoption of this method at an annual cost no greater than the interest on the investment for one of the more expensive pavements. For some reason which is not clear, it is considered in many communities that it is decidedly uneconomical to invest money for maintenance. It is hard to perceive virtue in this argument when it is applied to salvaging existing roads, provided the expense is no greater than the interest upon the investment necessary for construction of expensive pavements which require little maintenance. It is not fair, however, to neglect to consider the character of service rendered traffic. Adoption of surface treatment therefore is hardly in order unless smooth surface comfortable to ride upon results.

Surface treatment of gravel and surface treatment of macadam are somewhat different problems. In surface treating a gravel road it appears to be essential to employ a bitumen which has some penetrating power and which therefore does not lie upon the top in the form of a mat. Excellent results in surface treatment of gravel roads are secured from the use of cut-back asphalts which are very fluid and which seem to acquire a more intimate bond with the gravel surface than do more viscous materials. In some localities the plan of using a priming coat of light material of very low viscosity followed after an interval of a few weeks by a treatment with a heavier material is favored.

The surface of a well built macadam road swept free from dust, ordinarily may be treated with execllent results with the more viscous asphaltic oils. It appears to be the sentiment now in most localities that the heavy asphaltic oils are more desirable for surface treatment of macadam surfaces than are the light dust laying oils used so commonly a few years ago. It is questionable, however if the use of the more expensive heavier products is desirable if the road surfaces are destroyed annually by frost action. Successive treatments of a well built macadam road not subject to foundation weakness develop with proper maintenance a surface capable of standing up under heavy traffic. The accumulative benefit of successive treatments cannot result if a road is weak so that the surface completely breaks up annually as a result of frost action.

Corrugation of surface treated roads is considered by many to be a serious defect characteristic of this type of surface. Ordinarily excessive corrugation is due to the selection of improper materials or to the accumulation of too great an amount of bitumen upon the surface. More frequent light applications of bitumen are considered to be more effective than less frequent heavy applications. Many times also it is considered good judgment to touch up spots where the surface treatment is defective rather than to apply to the entire surface a coat of bitumen which may result in an excess upon the surface and consequent corrugation.

Asphalt Macadam.—The technic of the construction of asphalt macadam appears to have received less attention than has the technic of the construction of the higher types of asphalt surfaces. Perhaps this may explain the prejudice upon the part of many highway engineers against this type of pavement. It is a fact that in many sections asphalt macadam has proved to be a very inferior type of surface, hardly preferable

to several cheaper surfaces. On the other hand there are in the United States many instances of very economical service having been rendered by asphalt macadam pavements under heavy travel. In Rhode Island we have asphalt macadam pavements rendering economical service upon roads carrying a maximum daily traffic of approximately 10,000 vehicles per day and a daily average for the entire year of approximately 4,000 vehicles per day. Some of these surfaces are 10 years old, and are in excellent condition.

Some of the faults characteristic of asphalt macadam pavements in many sections are corrugation of the surface and local raveling of the surface due to improper bond. Perhaps the most common fault, however, is foundation defect, which should not be considered necessarily as detracting from the merit of the pavement.

Excessive or progressive corrugation of the surface can be eliminated by careful selection of materials and by proper attention to numerous construction details. Raveling of the surface also may be overcome. Although there are many highways upon which asphalt macadam is not desirable, it appears that asphalt macadam properly built will serve admirably upon a great many roads carrying fairly heavy travel.

The result of improper selection of materials for asphalt macadam pavements perhaps is more spectacular than is the case with some other asphalt surfaces, and the result is more quickly perceptible. We favor for the construction of asphalt macadam the selection of hard and tough stone. For very light traffic, of course, stone which is softer and less tough may be practicable. Since our practice of asphalt macadam construction contemplates that the stone in the penetration course will be subjected directly to the abrasion and impact of traffic, our reason for selecting hard, tough stone is apparent. We do not believe that an appreciable excess of bitumen upon the surface is desirable, so that it appears to us that a stone must be used which successfully will withstand the effect of abrasion and impact of travel directly upon it.

We believe also in the use of three sizes of crushed stone in constructing an asphalt macadam surface, each size to be screened between close limits. The stone into which the asphalt is introduced, which we know as the penetration course, is specified to be of sizes passing a 2½-in. screen and retained upon a 1½-in. screen. After the first penetration of the asphalt a smaller size of stone is selected to fill the surface interstices. We believe that this keystone, as it is called, should be of sizes which, while readily permitting the separate particles to enter the surface voids in the penetration course, will not so completely close it that the second application of bitumen, or the sealcoat as it is called, will not penetrate. Ordinarily we specify the keystone to be of sizes passing a 1-in. screen and retained upon a ⅝-in. screen.

After the application of the sealcoat we favor a cover stone of sizes smaller than the keystone so that the smaller surface voids remaining after the sealcoat is applied may be filled by the cover stone. Ordinarily we specify that the cover stone shall be of sizes passing a ⅝-in. screen and retained upon a ⅜-in. screen.

The sizes of stone indicated above as the sizes called for in our specifications contemplate primarily the use of basalt and diabase. Occasionally the use of one of these rocks is not practicable, so that some other rock must be used. In that event, our sizes do not conform exactly to the sizes referred to above. We have no definite rule for correlating the sizes of crushed stone to the quality of the rock, but from our experience over a long period of years in crushing different types of rock which are common in our state, we are able to select the sizes which seem to work to the best advantage. Our best results have been achieved from the use of asphalt and diabase.

For asphalt macadam construction we favor the use of bitumens of penetration between 90 and 100. In some cases where our roads are canopied by trees we employ a material somewhat softer. If stability of surface is to be secured, we believe that the use of materials softer than 120 penetration should be eliminated.

In the construction of our asphalt macadam pavements we also insist that the penetration course of stone shall be uniformly 2½-in. in depth. Below the penetration course we employ a base of crushed stone which is sand-filled, and which is of uniform depth from 2½ in. to 5½ in., depending upon character of foundations, upon character of subsoil and upon traffic. We do not believe in attempting to penetrate a single course of stone of depth greater than 2½ in. after compression because we feel that proper compression is impossible and because we feel that the asphalt finding its way below the 2½-in. level is of no practical value.

We favor the use of a liberal amount of asphalt. Our specifications provide for the use of 1¾ gal. of asphalt per sq. yd. of surface for the penetration course and from ¾-gal. to 1 gal. per sq. yd. for the sealcoat. These quantities are employed where basalt, diabase or similar rock is employed. Where a soft stone is used, we employ less asphalt because the breaking of the stone under the roller with the consequent reduction in percentage of voids is very apt to result in a soft pavement unless the quantity of asphalt be reduced. If the better qualities of stone are used we experience no difficulty from softness of pavement surfaces constructed with the amounts of bitumen referred to.

We feel that the importance of rolling asphalt macadam roads frequently is overlooked. Our base course of crushed stone always is rolled until there is no perceptible motion under the roller. The sand filler is applied in small quantities during the rolling operation so that it does not blanket upon the surface. We favor also heavy rolling of the penetration course of stone previous to the application of bitumen. Unless a soft stone is used which breaks up badly under the roller, we perceive absolutely no merit in the theory frequently advanced that heavy rolling of the penetration course of crushed stone previous to the application of the asphalt is injurious. We attempt to secure the maximum mechanical bond possible previous to the application of bitumen, so the asphalt serves primarily to intensify and preserve the mechanical bond.

Spreading the keystone is given great attention in our practice. The riding surface is no smoother than the surface at the end of the process of spreading the keystone. Bunching of the keystone results inevitably in an uneven wearing surface. The use of insufficient keystone to fill the voids results in an improper mechanical bond and an open mosaic surface which is subject to raveling. A wide brush attached to a frame fastened to the steam roller is found to be very effective in securing even distribution of the keystone at a nominal expense.

After the application of the keystone, the pavement is well rolled before the sealcoat is applied. Subsequent to the application of the sealcoat, the pavement is rolled at intervals for at least one week. The final or back rolling we believe to be very essential in this type of construction. Subsequent to the initial rolling after the sealcoat is applied, the periods during which our final rolling is carried out are the periods of the day during which the temperature is the highest and the

pavement in consequence most plastic. If possible we prefer to open the pavement to traffic before the final rolling is completed. The effect of final rolling, together with the effect of traffic, appear to be more effective than does final rolling without traffic.

We favor distribution of asphalt by one of many highly developed motor distributors. We do not favor gravity distribution. Distribution under high pressure we believe to be essential in securing uniformity in distribution and effectiveness in distribution.

Asphaltic Concrete.—The technic of the construction of asphaltic concrete and sheet asphalt pavement is very highly developed. One cannot afford to deviate decidedly from the methods of construction of these pavements, which are well standardized. There are a great many types of asphaltic concrete so that no attempt will be made to discuss in detail each of the many types. Information concerning all of the types is readily available and in large part is dependable.

In the majority of types of asphaltic concrete it appears to be particularly essential to secure the maximum density which is practicable. It is particularly important to investigate carefully the grading of the fine particles in the mixture. It is generally considered desirable to secure a grading of sizes of particles passing a 10-mesh screen which conforms substantially to a standard sheet asphalt grading. Manifestly of course the proportion of material passing a 10-mesh screen must be correlated to the coarser particles in order to secure stability.

Recently intensive study has been made of the reason for corrugation in bituminous concrete surfaces and in sheet asphalt surfaces. It has been found that excessive corrugation of these surfaces in the majority of cases is due to the improper grading of the mineral aggregate, especially lack of filler, and to the use of asphalt of improper consistency. The use of excessive amounts of asphalt also is considered to be one of the causes of excessive corrugation. In preparing mixtures of these types it appears to be absolutely essential to correlate the asphalt binder to the mineral aggregate according to methods which are well defined.

Until very recently it has been considered generally that pavements of this type should be laid upon monolithic foundations. Recently there has been a tendency in many quarters to favor the use of resilient foundations. Excellent results frequently are secured from the use of macadam bases under the surfaces of both types. One of the finest examples of sheet asphalt in the city of Providence, R. I., is laid upon a macadam foundation. This particular pavement is in the neighborhood of 10 years old and is laid upon a narrow street which carries a car track in the center with the result that the heavy traffic passing over the street is more or less concentrated centrally between the car track and each curb. This pavement at present shows no evidence of fatigue.

The use of black bases, so-called, is a recent development. Arguments in favor of the use of such bases usually are that a resilient base of that character reduces the effect of impact to the surface and that it permits a more intimate bond to be secured between the surface and the base. Those who are in favor of bases of this type as opposed to monolithic bases argue that a monolithic base under the impact of travel in effect serves as an anvil to the detriment of the surface. The use of black bases is so recent that a large number of definite results based upon long years of use are not available. The writer is of the opinion that a monolithic base is preferable where the subsoil is unfavorable and where the traffic is concentrated in narrow channels by reason of the existence of car tracks in the street or for some other reason. It appears that the use of black base is desirable in many cases.

Sheet asphalt perhaps is better standardized than is any other asphalt pavement. The writer has no suggestions to offer in regard to the construction of sheet asphalt surfaces except to suggest following the best standard practice.

Maintenance of Asphalt Surfaces.—Ultimate success in the use of asphalt pavements depends as much upon successful maintenance as upon successful construction methods. Methods of maintenance which tend to destroy uniformity in the surface inevitably result in shortening the life of the pavement.

It seems logical to suppose, therefore, that repairs to pavement surfaces should be made with materials similar to the materials employed in construction, and that the methods employed in using the materials should be substantially identical with the methods adopted in construction. Repairing of breaks or cuts in bituminous concrete surfaces and in sheet asphalt surfaces ordinarily is taken care of by replacement with mixtures such as were used in the original construction. In maintaining asphalt macadam surfaces, however, it is common practice in many sections to employ only the simple and expedient method known as cold patching. Cold patching also is employed in some localities extensively for maintaining some of the cheaper forms of bituminous concrete.

The use of cold patches in asphalt pavements of the better type well may be considered as questionable practice except as a temporary expedient to take care of the situation until more permanent repairs may be made. Our department strongly favors the use of asphalt macadam patches upon asphalt macadam roads and upon asphaltic concrete roads where coarse, ungraded aggregate is employed. We recognize, however, that it is not always possible to put in a patch of this type as soon as a cut or break occurs. Therefore we use cold patches upon this type of surface only as temporary expedient until it is convenient to make a more permanent patch.

In our asphalt macadam roads patching of holes seldom is required except where cuts are made for the purpose of installation or repair of underground public utilities structures. Our repair of bituminous macadam roads consists very largely of light touching up of spots in the surface which are porous as a result of unequal distribution of the bitumen. For this work we favor using an asphalt of approximately the penetration used in the construction of the road. We believe that this practice tends to promote uniformity in the surface and thereby favors the securing of the maximum economical life of the surface. We do not favor for this local surface repair the use of light cold materials.

Cold patching appears to be particularly adapted for use upon surface treated gravel roads and upon surface treated macadam roads. For the repairing of breaks in either of these surfaces it is almost out of the question to attempt to restore the surface in the manner in which it was built.

A feature of maintenance aside from light repairs which is customary upon all types of asphalt surfaces, except upon sheet asphalt and similar surfaces, is resealing with asphalt at intervals of several years. It has been remarked previously that danger sometimes attends the practice of employing upon surface treated gravel roads and upon macadam roads too frequent applications of bituminous concrete surfaces. We have in our state bituminous macadam surfaces which are ten years old and which never have been resealed. The accumulation of excess bitumen upon the surface we believe is dangerous because it tends to promote cor-

rugation of the surface and tends also to make the pavement excessively soft during warm weather.

We take care of local abrasions to the surface and of spots where the surface is porous for some reason by local treatment only. We can see little excuses for applying a sealcoat to the entire surface of the pavement simply because there are a few local defects. The tendency of asphalt in bituminous macadam construction is to flush to the surface under the effect of traffic and the sun. Our asphalt macadam roads take about three years to arrive at a typical asphalt surface. To one who is familiar with asphalt macadam construction it is very apparent when resealing is necessary. In general it may be said that resealing is necessary only when the entire surface shows a tendency to become porous. Repairs to our bituminous macadam roads are taken care of by section gangs equipped with heating kettles and such other minor equipment as permits the use of hot asphalt.

What has been said concerning resealing of asphaltic macadam roads applies in general to resealing of asphaltic concrete roads. It appears to be true that many pavements of both types are injured almost beyond redemption by injudicious resealing. It is not always a case of too frequent or too liberal applications of bitumen to the surfaces, but it is sometimes a case of the use of improper materials. We do not favor the use of soft products for resealing the surfaces of either type. For resealing bituminous concrete surfaces we favor the use of a paving cement of from 60 to 70 penetration. For resealing of bituminous macadam surfaces we favor the use of an asphalt of penetration between 120 and 150. Ordinarily we employ machine distribution of materials in resealing asphaltic macadam surfaces. For resealing bituminous concrete surfaces we favor the squeegee method because it appears to be difficult to secure a uniform distribution sufficiently light by motor distributor.

The amounts of material used for resealing should depend upon the character of the surface which is treated. It is our intention not to form a mat upon the surface but to make the surface water-tight by filling the small voids in the surface which may develop under traffic.

It would seem that one of the common faults in maintaining asphalt surfaces of the higher types is that sufficient thought is not given to the question of prolonging the life of the pavement, but the immediate demand for a smooth surface is supplied in the most expedient way only. In general attention to the plan of designing maintenance methods to the end that maximum life of the pavement may be secured is considerably to be desired.

BITUMINOUS CONCRETE AND PENETRATION MACADAM.—The following by E. A. James appeared in Roads and Streets:

Preparation of Base.—Any foundation that is suitable for bituminous concrete is in my opinion suitable for penetration surface but the converse is not true. A paper on foundations will deal with the type, thickness and method of construction, but it is within the province of this paper to deal with the surface of the foundation, because the wearing qualities of the surface depend in a marked degree upon the bond between the surface and the foundation.

If it is an old macadam foundation the road should be swept but I have no objection to leaving on the old macadam surface live bitumen that may have adhered from surface treatment, provided that it is uniform in its application. If it is not uniform and exceeds one-third of a gallon to the square yard it should be removed, otherwise there is a danger of the bitumen from your surface penetrating and cutting back the tar of the old surface treatment to such an extent that you will get excess tar and therefore movement in certain patches of your new road. If, however, the tar from the former surface treatment is reasonably uniform, in applying your new penetration you can make allowance for this.

When building new macadam base for penetration surface we sweep the base until the body stone project. We are of the opinion that many penetration roads have been ruined by leaving a film cake of fine lime between base and surface course. If it is an old brick road which is being surface treated, great care must be taken in evening up the brick surface with a lean mix of stone and bitumen. This filling will be carried on until you have a road camber which will permit of a uniform thickness in the wearing surface.

A concrete base should be left rough. Our preference is for raking it with a wooden rake at right angles to the line of traffic. The marks left by the rake should be approximately ½ in. wide, ½ in. deep and 4½-in. centers. With such markings, rolling the the penetration surface keys the material and even with excessive bitumen there is very little danger of movement.

For bituminous concrete when old base is being used much greater care must be exercised than with surface penetration.

Experience with Hot Top.—From our experience in laying hot top during the last four years I have been forced to the conclusion that it is bad engineering to lay hot top unless a curb has been constructed. I have tried shoulders, hoping in this way to prevent any side movement in the hot top surface but so far we have failed. There should be no excess bitumen in hot top and just as sure as you get side movement you get a perceptibly weaker pavement. This criticism does not apply to the penetration surface because we know the penetration surfaces carry excess bitumen and little openings are immediately healed in warm weather.

We are, therefore, of the opinion that hot top on a macadam base is a type of construction that will not be continued, unless curbed.

Where curb and gutter are constructed it is necessary that the macadam base be swept absolutely clean and this base must not be an old bituminous base unless you are satisfied that the bitumen is less than 4½ per cent of the base. In other words the usual penetration macadam must not be used as a base for hot top. If it is used you will find the bitumen in the base will cut the bitumen in the surface and a rolling, soft pavement will result.

Marking Concrete Base.—A concrete base should be left rough no matter whether you use close or open binder. It costs but little and it adds materially to the life of the pavement. In the case of the hot top the markings, if with a rake, should be made both ways but not so deep as for penetration but at about the same centers. One of the best markers we have used is a coil of rope fastened to a tamper. The surface is stamped before the concrete has taken on such a set as will interfere with the strength of the base.

Cause of Creeping.—By far the greater percentage of creeping is due to the lack of bond for the base and wearing surface. A comparatively thin wearing surface, not bonded to the base, develops both temperature and traffic stresses that cause the wearing surface to move. Rolling and cracking follow and the pavement distintegrates. In the mixture itself uniformity in the raw materials is an essential. Variation in the percentage of contents must only be permitted within small limits as carelessness or ignorance in proportion-

ing the mixture is without doubt the greatest cause of failure in bituminous concrete pavements.

In connection with mixing, care should be taken to prevent unmeasured asphalt to get into the mix.

Sheet Asphalt.—Any change that we have made recently in sheet asphalt has been to increase the binder, which is a close binder, using a thinner wearing surface. We think that the binder serves two purposes, one to prevent slipping on the base and the other to distribute the load over a greater bearing surface. If for any reason ½ in. of the wearing surface is removed the pavement should be repaired even if the wearing surface is 1½ in. So our preference is for a 3-in. pavement, 2-in. base and 1-in. wearing surface.

Of course, the material should be brought to the work at the proper temperature and then proper raking and spreading are essential. Of the many mechanical processes in connection with paving, raking is one of the most important and yet most difficult for some to accomplish successfully. It appears to be an art in itself. While a good raker is important, an experienced rolling man is also essential. The temperature at which it may be rolled, the direction and intensity of rolling, are matters of judgment which can not be definitely set by specifications.

Penetration Macadam.—In penetration pavements the selecting of the stone is very important. Our experience has shown that a uniform 2-in. stone is to be used. A stone that breaks cubically will allow of greater penetration than a stone that slivers. The first keying should be done with ¾-in. and the keying finished with ⅜-in stone.

I noticed in a recent inspection of British road construction that the better penetration roads are hand poured. The resident engineers claim that they can get more uniform penetration because there is not consolidation from the wheels of the trucks and if, for any reason, small areas become consolidated it is easy to rake them so as to secure sufficient penetration.

On our work we find, however, it is almost impossible to get men who are willing to hand pour bitumen, so that with our mechanical appliances our first care is to prevent uneven consolidation. We never allow the tar trucks to pass along the loose stone under their own power. We haul them with the road roller. We also keep a man with a rake working just ahead of the spray to make sure that foreign substances are removed and consolidation in the stone loosened. We use hand nozzle and prefer it to the manifold.

No matter what care is taken with loading the bitumen in the manifold we find stoppage under the individual sprays that leave weaknesses in the road. We have not had much difficulty in the training of men to handle nozzle as after a man with judgment has completed a couple of tanks he knows from the color of the mat approximately the quantity he has applied.

After the first application of bitumen, which we usually make slightly over a gallon per square yard, we add three quarter stone and roll until there is no movement. This rolling usually leaves a film of dust which we broom from the surface and add a second application of slightly more than a half gallon covering it with three-eighth chips, rolling and sweeping until the mat is formed and the road waterproof.

We then throw the road open for traffic and either that season or in the succeeding season apply a coat of light bitumen which we cover with very coarse sand or pea gravel. Even on the heavy traffic roads our experience is generally that it is 3 years before further attention is required and then an application of ¼ gal. per sq. yd. of light bitumen appears to make the road as good as new. We have not had success with coarse rolling on our penetration roads. Commencing at the edge and working to crown on longitudinal rolling we find a better practice.

ASPHALTIC CONCRETE CONSTRUCTION.—Chris P. Jensen, County Surveyor of Fresno County, Calif., gave the following in Roads and Streets:

In Fresno County 152 miles of county highway 16 ft. wide have been constructed in which the entire structure is of asphaltic concrete 5 in. thick. Recently contracts were also awarded for the construction of 7 miles of 5 in. and 11 miles of 4 in. asphaltic concrete highways. More are to follow. In 1909 the city of Fresno commenced extensive asphaltic concrete pavement construction and since then with little interruption, this type of pavement has been the accepted standard. The maintenance on all these pavements has been negligible.

The base course in the above pavement contemplates a 3½ in. thickness, and the wearing surface specifications contemplates a thickness of 1½ in., making a total thickness of the combined structure of 5 in.

I desire to direct particular attention to those clauses in the specifications requiring 1,000 lb. of mixture to cover only a specified maximum area of surface. We have found this specification to work out most successfully, and incidentally it removes one of the greatest points of contention between the contractor and owner. This ratio of weight to area is based upon a mineral aggregate having a specific gravity of 2:80; if a mineral aggregate having a less specific gravity than 2.80 is used, it will result in a slightly thicker pavement, but at no extra expense to the contractor, for the reason that mineral aggregate in California is commercialized on a tonnage basis.

Proportions of Mineral Aggregate.—The actual proportions of mineral aggregate used in Fresno County work and being in conformity with the requirements of the specifications will generally run about as follows:

From bin No. 4 (large rock)	450 lb.
From bin No. 3	200 lb.
From bin No. 2	100 lb.
From bin No. 1 (fines)	250 lb.
Total	1,000 lb.

To which is added 45 lb. of asphalt of approximately 45 degrees penetration, standard No. 2 needle; the ductility of the asphalt is never less than 100 centimeters by the standard ductility test.

The fact that in Fresno County asphalt of 45 degrees penetration is specified does not necessarily point to the use of this consistency throughout the United States, or even the west. The proper penetration to be used in any particular community should be the expression of the engineer's best judgment, after carefully considering climatic conditions.

The 200 Mesh Material.—It has been common practice in the manufacture of asphaltic concrete to use hydralic cement, or lime dust, or the by-product of sugar beets, to supply the necessary quantity of 200 mesh material, oftentimes lacking in fine aggregates. We wish to emphasize our experience that this practice results in a much inferior pavement than if these adulterations are eliminated; we therefore insist upon the importation of a sufficient quantity of 200 mesh sand to bring the mineral aggregates to the proper proportions. I might mention here that in one case a local sand material was found in which the 200 mesh material predominated, resulting in the contractor having to install a blower to eliminate the surplus dust as the materials went through the heating rollers.

Paving Plants.—The paving plants operating in the west are usually of three sizes: of 1,000 lb., 1,500 lb. and 2,000 lb. capacity each.

The devices for heating the mineral aggregate may be of the even drying type, or by direct flame applied as the mineral passes through rotary steel cylinders.

Considerable expert knowledge is required for the proper mixing and laying of an asphaltic concrete pavement, and the lack of experienced labor, and inspection, will in nearly every case prove disastrous. A sieve analysis of the aggregates should be made at least every hour at the plant, so that any material variations in the uniformity of the aggregate may be instantly detected and corrected. It is necessary that the asphalt be stored in waterproof containers, because the infiltration of even the smallest amount of moisture will cause the asphalt to foam. Great care must be exercised by the mixer operator in weighing the proportions of aggregate from each bin; it is very easy to permit a few extra pounds of aggregate from any one bin to enter the mixing mill by the careless manipulation of the scales and gates.

In warm weather we prefer to keep the temperature of the mixture from 250 to 260° F.; in cool weather we generally employ a temperature of about 280° F., subject to variations made necessary by conditions of distance hauled.

Spreading and Rolling.—In spreading the mixture on the grade, we insist that the truck drivers become so experienced that the material can be spread upon the previously measured area so uniformly as to render it necessary to make but little adjustment with shovels; we find this method to be superior and more efficient than the use of mechanical spreaders.

Rolling is a very important step in the construction of a proper asphaltic concrete pavement, and particular attention is given to this detail. Two 12-ton 3-wheel rollers are always on the job, and rolling is continued until no further compression is possible, and until the mixture has assumed its proper specific gravity, and will show no further marks by the rollers. Transverse rolling is always employed on city streets, but in the case of comparatively narrow highways, transverse rolling cannot always be accomplished; diligent diagonal rolling is, however, required.

Inspection service is strenuous, both at the plant and on the street. Every operation is under constant control, and the resultant mixture very carefully watched. The plant inspector indicates the weight of every truck load of material on a card, which is taken by the truck driver to the inspector on the street, who then marks off the proper area upon which the material should be spread. Adjustments are made where necessary owing to inequalities in the subgrade.

Raking, as you all know, is also an important factor in producing good results, and it is useless for any inexperienced men to attempt this work.

As an aid to maximum plant output, we find it advisable to have provided a compartment under the mixer to receive the contents of a mixer batch. By this expedient the mixing of materials will not be delayed by reason of a short delay on the part of trucks.

In ordinary weather a load of mixed materials will retain its temperature remarkably well. We have frequently hauled this material 20 to 30 miles with a loss of only 4 or 5 degrees in temperature.

Traffic on Base Course.—We do not hesitate to permit traffic on the base course, after it has cooled. In fact we frequently lay a stretch of base 5 miles or more in length and permit the contractor to haul the wearing course mixture over it, up to a total gross truck load of 12 tons. We encourage the distribution of this traffic over the entire width of base, so that any serious defects in the subgrade will develop before the application of the wearing course, and any unevenness be corrected and absorbed by it. We find under such procedure, that after a few weeks of traffic over the complete pavement that the whole structure has become blended into one compact and integral mass.

In mixing the materials in the plant, we prefer that coarse aggregate be placed in the mixing mill first and then fines and asphalt added gradually, so as to produce a complete and effective covering of every particle of stone with asphaltic cement.

Mineral Aggregates.—Fresno County has employed coarse mineral aggregates of both rounded gravel surfaces and of crushed quarried stone in which, of course, all surfaces are angular. The results of our experience are interesting. Contrary to the usually accepted theories, we obtained the better results with the use of round surfaces. We find that the crushed rock will bridge, one particle of stone against another. This bridging action is so effective that, unless crushed under the roller, it will prevent a thorough compaction. On the other hand, gravel aggregate having rounded surfaces will permit of sufficient displacement, internal movement or adjustment, under the action of the roller, so that a much greater degree of compaction will result than in the case of quarried stone.

The ultimate result in this case of a gravel aggregate is a smooth riding surface, and in the case of quarried rock, the fine aggregate tends to settle into the larger interstices of the coarse aggregate, after a period of two or three months traffic, and results in a highly corrugated riding surface.

In the west, where asphaltic concrete base is used, 85 per cent of the pavements are of a total thickness of 5 in. or less, including the wearing surface.

PENETRATION AND SURFACE TREATED MACADAM ROADS.—K. I. Sawyer, County Road Superintendent, Marquette County, Michigan, gave the following in Roads and Streets:

At the time the volume of motor traffic began to advance with the rapidity with which you are all familiar, some eight years ago, our district contained a considerable number of water bound macadam roads. In all instances in Marquette County the roads were built of trap rock, granite or quartzite. Our trap rocks are excellent for wear resistance, but the cementing quality in water binding is usually below that of a lime rock, whereas the granite or quartzite stretches were usually bound with clay and stone dust mixed, the rock powder from these latter rocks having a cementing value of practically nil. We had very little granite or quartz rock macadam.

The First Surface Treated Road.—This traffic, which traveled the plain water bound road, coupled with the financial necessity of using our roads as long as they could be made to give reasonable service, induced us to turn to surface treatment of these roads. The first stretch worked in this way was the road between the cities of Negaunee and Marquette. This road was reconditioned under traffic in the years 1916 and 1917, the work really being in the nature of a light water bound resurfacing, and the road was treated, as fast as it was put in shape, with a surface treatment of refined tar at the rate of ½ gal. to the square yard. The cover used on the tar was washed pebble passing a ⅝ in. screen from a pit which contained chiefly granite pebble or ¾ in. rock chips with all dust removed. The cover was applied at a rate of approximately 70 tons per mile. The width of the treatment was 15 ft.

The following year a second surface treatment was

made on this road, using ¼ gal. of tar to the square yard, and approximately the same amount of chips or pea gravel, as during the first application. All of this road had received its second treatment by mid-summer of 1918, and has not had a re-treatment since that date.

Maintenance and Traffic on the Road.—Maintenance has been of the continuous patrol type. To supply the patrolman with materials, barrels of tar are buried into the road slopes or sides at convienient places, and frequently piles of cover gravel are stocked upon the shoulders.

The maintenance of this section, which is approximately 8 miles in length, is handled by one patrolman. He is given extra help immediately following the spring break-up so as to quickly patch up the entire length of the road, and at the same time shoulders are built up, any cold patch work required is done, and then for the balance of the year the road is kept up by one man. Paint patch methods are followed.

This road has now been in use more than 5 years since its last surface treatment, and under traffic varying from 800 to 2,500 vehicles per day. It is expected to give this road a ¼ gal. treatment next year. The surface of the road is in very good shape with the exception of a few short stretches where foundation troubles are manifesting themselves on the surface in cracks or settlement which has required cold patching.

Mileage of Surface Treated Roads.—I have gone into detail purposely upon this one section because it was our first stretch, and because our present practice in handling this work was developed upon it. We follow substantially the same line of operation upon all of the surface treated roads, and we now have of this surface treatment type in use the following roads:

Old macadam reconditioned and surface treated with tar	17 miles
Class C—gravel macadam, tar treatment	3 miles
Class B—gravel, tar treatment	3 miles
Rubble base course, hot asphalt treatment	4 miles
Rubble base course, tar treatment	11 miles
Total	38 miles

Not including work done in the cities.

This latter type, or rubble base course, is a special specification road in which a heavy bed, usually a foot thick, of waste mine or cheap quarry rock is built and smoothed up, expecting this to be the bottom course of a penetration road in the future, but which is to be used as a 1-course road for the present, and is surface treated for that purpose. The object of this type of construction is to get more miles of road immediately usable from the same amount of money. Using the bottom course as a road also delays the period of the first re-surfacing of the finished road and develops the traffic requirements prior to building the completed road.

Comments on Surface Treatments.—Commenting on surface treatments, I believe it is proper to emphasize first and all the time, the importance of cleanliness. This is not a new treatment, but it simply cannot be over-advocated. The hot surface treatment seems to require approximately twice as much cover material as we usually put on the cold treatments, but in this connection I should call attention to the fact that I am a believer in using the very minimum of cover material which it is practicable to use and accomplish the object of the treatment. Our cold treatments are always heated to around 100° F.

I do not believe that a surface treatment should be made with the idea that it will recondition a wornout macadam road. The road should be reconditioned first. A surface treatment in final analysis is a painting proposition and it is primarily preservative in its operation, with the added advantage of abating the dust nuisance.

Construction of Penetration Type.—Penetration roads are not new in road building and no mention need here be made of the methods of construction. We have only been building them on the country roads for about 3 years in our district, but I have personal knowledge of several stretches under city traffic which are 8 to 10 years old which are in perfect shape, and have had very little maintenance other than cleaning.

When it became necessary to rebuild a 6-mile piece of old macadam road on M 15, south of Marquette, an inspection showed that traffic could be diverted from the road by detours. The available rock was suitable for any of the usual types of road, but the best available rock was a quartzite, unsuitable for water bound macadam, and it appeared that to reconstruct this road as a water bonded road would cost substantially as much as to build a penetration top. It might be pointed out that in these two types of construction, i. e., surface treated, water bounded or penetration macadam, the penetration bitumen with keystone and chips takes the place of the dust, water bounding and surface treatment, and that otherwise costs usually remain nearly the same, so that when traffic can be detoured, a penetration road is usually preferable to a water bound surface treated roadway, both as to ultimate economy and as to service.

For these reasons the old macadam on this M 15 was shaped up and widened to form a base course and a 3 in. penetration macadam top built upon it. The road has gone through 3 years of heavy and mixed traffic with practically no repairs to the traveled way, and only the usual shoulder, ditch and roadside maintenance. The maintenance being of the continuous patrol type, one man working full time upon the section which comprises the entire 6-mile stretch. Most of the work has been upon the shoulders, as this is a light soil district and the grass is only now starting to give much protection from erosion of the slopes and shoulders.

We also have 8¼ miles of penetration macadam on M 15 west of Ishpeming, and 2 miles on one of the county trunk highways connecting one of the larger mining towns with the state trunk highway. Both are very satisfactory roads, built with a mine rock lower course and quartzite rock tar penetration tops.

Concerning the construction of macadam roads, there is one feature of the specifications of our state highway department with which I am not in accord. As I read their general specifications, any of the macadam types of road may be built with stone having a coefficient of wear as low as 7, a toughness as low as 7, and a hardness as low as 14. The variability of our rocks early directed out attention to the matter of rock selection, and from what I have seen of the service rendered by rocks of various character, I believe that these values are too low for the wearing or top stone.

In all our costruction we aim to use a rock having a coefficient of wear of not less than 10 in the surface or top course. Careful canvass of the supply field will usually make it possible to better the state specification low limit of quality at least, and in our vicinity it usually adds little to the cost to get our desired minimum of quality in the stone.

It is my opinion that rocks meeting the requirements in the specifications of the state highway department, above mentioned, are sufficient in quality for use in the lower course, and I believe that economy may be secured in many instances by using a poorer rock in the lower course, though possibly of larger sizes than now specified, and good rock in the wearing course. The thickness of the lower course made of the cheaper

rock can then be varied where necessary to accord with the supporting power of the earth sub-grade.

With the present demand upon road money and the disposition to spread it out, care should be taken in making any road design thinner until it is proved that theory and good practice are in accord. Particularly in these cheaper types of roads, if we should err it should be on the side of excess mass.

Causes of Failure.—Nearly all of the failures I have seen in either penetration roads or surface treated water macadam were apparently from one of two primary causes, or at least these causes contributed to the failure, and these are the design of the lower course with regard to thickness and the bearing power of the grade and the quality of the stone.

In general these types of road are applicable under medium to heavy traffic when proper supporting strength for the traffic load is possible of accomplishment. They will be found, if properly built, pleasing to the traveling public and fairly easy to maintain.

CONSTRUCTION OF BITUMINOUS CONCRETE ON TREATED GRAVEL BASE.—The following is from an article by W. E. Grayson of the Michigan State Highway Department in Roads and Streets:

At the clase of the 1924 paving season the Michigan State Highway Department will have laid approximately 150,000 sq. yd. of bituminous concrete on a treated gravel base.

The state owns and operated a semi-portable plant equipped with an oil burner drum from which this mixture was turned out.

While this class of construction is not new, it has attracted considerable attention for the reason that no single organization had gone into this class of construction quite so extensively. Many thousands of yards have been laid on broken stone but a comparatively small yardage has been laid where the old gravel roadway was used as a base.

The First Job.—The first job selected for this type of construction was 7½ miles on Trunk Line 43, between Kalamazoo and the village of Richland. Mr. Rogers, our Highway Commissioner, suggested that the gravel surface be treated with tarvia before laying the surface course. His suggestion was not very enthusiastically received by his staff but his instructions were followed. Subsequent results proved this to be the most important part of the construction. Briefly I will describe the methods used on this project.

An investigation of the soil and drainage conditions is first made. If they are favorable, a center line survey is run and the roadway is cut every 100 ft. to ascertain the thickness of the gravel; one cut on center line and one at each edge being made. The thickness of the gravel at each cut is measured and recorded by station number. If the gravel is of sufficient thickness (and we consider 6 in. to be the minimum), the project is advertised and let. Bids are asked for black base on a tonnage basis, and the surface by the square yard.

Shaping Roadway.—When paving operations start, a power grader is employed to shape the roadway to as near the finished pavement as is possible. A man using a template shaped to the finished cross section of the roadway accompanies the grader and checks its operation. The road is then swept clean, all loose material being pushed out to the shoulder of the road and about ¼ of a gallon of tarvia to the sq. yd. is then applied. A sufficient amount of time for all light oils to evaporate is allowed before surfacing operations are commenced.

We find that we get a penetration in the gravel surface from ½ to 1 in. which holds the metal in place and insures a perfect bond between the gravel and the surface coat. Wherever the surface breaks up under truck haul it is swept clean and filled with black base.

We start surfacing at a point nearest the plant, going back 1 mile; completing it and hauling over it to the next mile, and continuing in this manner until the contract is completed. By using this method the trucks do not break up the treated surface as they would if we started to a point furthest from the plant and built towards it.

The Black Base.—The roadway is leveled up with a black base of somewhat finer aggregate than that specified by the Asphalt Association and carries about 6.5 per cent bitumen. This base varies in thickness from 1 to 5 in. depending on the amount necessary to bring the roadway to the proper cross section. All gravel that is not firmly consolidated is dug out and filled with this material. Particular attention is paid to the edges and our truck drivers are instructed to drive close to the edge to find the weak places if any.

After this operation, pieces of 2 in. x 6 in., about 16 ft. long are strung along by a light truck; three ⅞ in. holes are bored in each piece and they are spiked along the curb line with iron pins 14 in. long and ⅞ in. in diameter.

The Surface Coat.—The surface coat is then laid. We are using an asphaltic concrete carrying 9.5 per cent dust, 21 per cent ½ in. crushed limestone of good quality and 56 per cent sand graded closely after Richardson's heavy traffic mix.

Particular attention is paid to the sand grading. A man is kept constantly employed testing sand and one taking temperatures. These results are recorded daily. The boxman, who weighs the material, is also checked two or three times daily by testing the weight of a loaded truck on heavy scales.

The surface coat averages from 2 to 2½ in., but must be no less than the former. All lumps must be broken up by rakers and a back man is employed to fill honeycombed places, if there are any, directly after the surface roll. Three power rollers and one 1,500 lb. hand roller are used. A 5-ton power roller surfaces with a straight roll. Immediately behind this roll the hand roller is used for a cross roll. A 5-ton roller then makes a double diagonal roll, followed by an 8-ton roller which also double diagonal rolls, taking out the stop marks of the 5-ton made when surfacing with straight roll. After the diagonal roll, the 8-ton straight rolls the entire surface and is followed by a 12-ton roller with a slow straight roll.

None of the roller men are allowed to speed their rollers. All are required to move slowly and half lap each roll. An electric light has been fitted on the 12-ton roller and this roller is used until the material is so cold that it makes no further impression. All the surface is straight edged behind each roll and low spots, if any, are filled at once and high places rolled out.

CONSTRUCTING TAR MACADAM.—Methods of constructing tar macadam are described as follows by John S. Crandell in Roads and Streets:

Preparing Subgrade.—Assuming the drainage has been taken care of we must shape up the ground of the old road bed to the correct sections, and roll it well. There is too often carelessness in this stage of the work, and later on it becomes apparent. See to it that your roller man does not roll waves into the subgrade for if he does they are liable to appear in the finished road. Fill in depressions and cut off hummocks so that when you ride over the rolled subgrade in your car it rides like a good dirt road.

The Base Course.—On top of the rolled subgrade the base course is placed. This may vary in depth from 4 in. to 12 in., depending on local conditions of soil, stone, and traffic expected. If old stone fences may be had for the asking or for less than broken stone or slag, use them, for they make an excellent Telford foundation. The voids must be filled with either gravel, chips, screenings or similar materials. While the voids are being filled the base is being rolled, and as the rolling progresses the fine stuff works down into the base so that more of it must be added. The roller must not exceed 60 lin. ft. a minute. Fast rolling like fast living leads to pitfalls and ruin.

If broken stone or slag is used in place of field stone it should be 3 in. stone. This is keyed by filling the voids with suitable fine material. The finished base looks like a waterbound macadam. In fact it may be used for a time as such.

Here let me pause for a moment to warn you to see to it that this base course, when finished, rides well, is free from depressions or irregularities of any kind. Those of you who have built bituminous bound roads know that this warning is well advised—those who have not yet tried it may profit by making a mental note of it.

The smoothness and easy riding qualities of the finished pavement depend largely on the finish of the base.

Don't let your roller man jazz up the rolling. If he does the base will be bumpy. Don't let him skimp on his work. Roll until the base is solid and does not move under the roller.

There is nothing difficult nor tricky about this. It is simply a matter of careful workmanship and attention to detail, which costs no more than slipshod methods.

The Wearing Course.—Before the wearing course is laid the base must be swept free of all dirt or loose material. If the base has been used for a few months it is liable to be rather dirty. In such cases a rotary broom or even a road scraper may be used to advantage.

It is possible to use an inferior quality of stone in the base with no detriment to the resulting pavement. It is not possible to do likewise with the wearing course. The best obtainable is cheapest in the end. There are many localities where the local stone is a suitable base building material, but unless you have a tough, hard metal available it may be economy to import the wearing course stone from some nearby point. It is not recommended to go to any great distance for such stone unless the local variety is utterly worthless. As a rule sandstone is not suitable for wearing course although it is permissible in the base. Hard limestone, dolomite, trap and some granites are satisfactory for the wearing course, as well as air cooled basic slag, free from flue dust.

Spreading the Stone.—Some form of stone spreader will reduce costs for both the wearing course and the base. A spreader does the work of several men and is recommended where labor costs are high.

Pockets of small sized stone or stone broken into dust by too much rolling must be removed before the tar is applied. If such pockets are allowed to remain then when the tar is sprayed over the surface it will form puddles at such places and fat spots will develop.

If a mechanical unloader is used there is no danger of the smaller sized particles all being dumped in one place. If unloaders are not used the stone should be dumped on unloading platforms at the side of the road and shoveled into place.

Again let me warn not to let the roller man speed; 60 ft. a minute is the maximum. If the base is uniform, free from hills and hollows and correctly crowned the rolling of the wearing course is easy. It is the duty of the inspector and the engineer to examine thoroughly every square yard of surface before the tar is applied. It is at this point that corrections may be made, dirty stone may be removed, depressions may be filled, waves may be rolled out, and other defects remedied. After the tar is on there is little that may be done.

As soon as the wearing course stone is rolled as much as it will stand or may be necessary the first coat of tar is applied.

Applying the Tar.—Years ago the manufacture of tar into refined products for roads was hit or miss. The crude tar was distilled until a certain number of pans of oil had been drawn off. The resulting product was chewed to ascertain if it was the desired consistency. If the chewers' jaws were tired he might reject the tar as being too hard.

In the last 25 years bituminous material have come to the fore so distinctly that numerous tests have been devised to insure the manufacturing of uniform products. The jaws of man have given place to the float test, the sp. gr. test, the distillation test and others. Today you may write a specification from which the manufacturer can make up a product that will be the same year after year.

Specifications for all classes of tar products for road work have been written and adopted by the leading technical societies and road associations.

The tar binder may be applied from hand pouring pots, from tank wagons or from suitable automobile pressive distributors. Great strides have been made in these last. It is now possible with the best of them to apply from 1/10 gal. to 2 gal. per square yard, and to vary the width of spray bar to suit the road. Some engineers prefer the single nozzle application for both the initial and the seal coats. Some like the single nozzle for first coat and spray bar distribution for seal, while others prefer the battery of nozzles for both first and seal coat work. With a well designed distributor any combination may be used successfully.

The depth of wearing course stone is usually 2½ in. and for this depth the tar is sprayed over the stone at 1⅜ gal. per square yard. If a 3 in. depth is used then about 1½ gal. per square yard is required. The binder should be heated to 250° F. and must not exceed 275° F.

Cover and Seal Coats.—As soon as the tar has been applied it is covered with clean ¾ in. stone which is rolled in. The excess stone is swept off. Then the seal coat of tar at 7/10 gal. per square yard is applied. The best results are obtained if this is applied from a battery of nozzles. A more uniform distribution is assumed.

This in turn is covered with what is known as the "cover," which may be stone chips or clean pea gravel. Whatever is used must be tough and hard. The cover determines the appearance of the road and also its surface texture. The hard chips make a skid-proof pavement that motorists are safe on. After the cover is spread the final rolling is given and the pavement is ready for traffic.

Within 60 days the road should be swept and given a second seal coat—this time with light refined tar, at ⅜ gal. per square yard and this is covered as was the first seal coat.

Tar Penetration Shoulders.—Many of the older roads are now too narrow for fast moving traffic. By widen-

ing them with tar penetration shoulders the roads are made suitable and safe. It is immaterial what type of improved highway is to be widened for the penetration type of construction lends itself equally well to cement concrete, asphalt concrete, or penetration pavements. The old National Pike leading from Baltimore to the West is being widened with tar penetration shoulders, so that the old 16 ft. road becomes 20 ft. road. It is said that the number of accidents has been reduced 75 per cent on the portion already widened.

In constructing penetration shoulders it is necessary to dig a trench on each side of the existing pavement. The depth depends on the location of the highway, traffic, and soil conditions. The edges of the old pavement must be trimmed up if they are ragged. A tandem roller that will fit in the trench is useful if it is to be had, but a 3-wheel roller may be used letting one of the rear wheels do the trench rolling. The method of construction is identical with that already described for penetration pavements. It sometimes happens that the job is not big enough to warrant the use of a motor truck distributor, and the tar may be heated in a tar kettle and applied from sprinkling pots by hand.

COST OF TAR SURFACE-TREATED GRAVEL STREETS.—D. B. Davis, City Engineer, gave the following cost data on work at Richmond, Ind., in Roads and Streets:

Method of Resurfacing.—As there is an abundance of good local gravel, that material was first used in the constructing of its streets some 25 to 35 years ago. The gravel was laid to a depth of 12 in. In the process of time these gravel surfaces required resurfacing, and it was decided to do this with the local gravel from the city's pit.

This new gravel surfacing was spread to a depth of from 4 in. to 5 in., when it was rolled and waterbound, as in macadam construction. Special care was given to the finishing process of the surface. This was done to more nearly satisfy the abutting residents with the low cost surfacing material. Then in 1919, it was determined to experiment with surface treatments of tar on these gravel pavements. N. 21st St. and N. 17th St. were the first ones treated. The success attained on these streets resulted in treating others each year.

Surface Treatment.—For successful results it has been our experience that the gravel surface must be firm and comparatively smooth prior to the application of the surface treatment. Better results are obtained if the gravel street is subjected to traffic for a season before applying the surface treatment.

The preparation of the surface consists in repairing all depressions by filling the same with ¾-in. stone, tamped to about 3/16 in. below the street surface and sealing them with hot tar. If there is dust on the surface, it can be removed to the gutter with a rotary sweeper. Otherwise good results have been obtained by applying the bituminous material directly to the gravel.

The tar was applied cold by means of a pressure distributor. For initial treatment, ⅓ to ½ gal. per square yard was used, with subsequent treatments of ⅛ to ¼ gal. per square yard. Better results are obtained by not applying any covering material whatever in the initial treatments. This allows the bituminous material to be absorbed by the surfacing gravel, which it does to the extent that, after traffic has ironed it out for a time, investigation shows that a crust has been formed of a thickness of from ⅜ to ½ in. Subsequent treatments are covered with a light sprinkling of pea gravel, to the amount of about 5 lb. per sq. yd.

Cost of Resurfacing and Treatment.—The city street department does the gravel resurfacing and applies the surface treatments with its own forces. The cost of resurfacing with gravel at present prices is approximately as follows:

	Per cu. yd.
Cost of bank-run gravel pit	$0.50
Hauling by teams, 6 loads per day, 1½ yd. per load; team at 65 ct. per hour	.72
Spreading on street at 40 ct. per hour	.13
Extra man at pit loading at 40 ct. per hour	.13
Cost of gravel on the street	$1.48

	Per sq. yd.
Gravel delivered and spread at $1.48 (5-in. finished depth requires 0.22 cu. yd)	$0.33
Scarifying and rolling	.07
	$0.40

The cost of the initial treatment of ½ gal. per square yard is as follows:

Gravel covering at $1.50 per cu. yd	$0.005
Binder f. o. b. track at 13 ct. per gal	.065
Cleaning and application	.020
Cost of treatment per sq. yd	$0.090

The cost of subsequent treatments of ¼ gal. per square yard is, $0.058 per square yard of surface.

Maintenance Methods.—It has been found that after traffic has used the treated gravel street for some months, a few depressions may develop, due either to an excess of dust, or a damp clayey spot on the surface prior to the application of the binder. These places will require looking after. This maintenance work is taken care of here by a maintenance repair gang, consisting of a team hauling a special wagon containing stone and sand, with the necessary tools, and back of which is hauled a tar heating kettle. This wagon was specially constructed for the work, the running gears being from a discarded horse-drawn hook and ladder fire wagon. The wheels are roller bearing, which permits the one team to haul the heavy load. The sand compartment in the rear holds 30 cu. ft. and the stone compartment holds 25 cu. ft. Under the driver's seat is a tank for the tar, to be used for very thin patching. The amount of material carried on the wagon will supply stone and sand enough for pouring 2 bbl. of tar, which is heated in the kettle at the rear. The kettle has a warming rack which holds an extra barrel, over which is a tight hood. The materials thus carried will supply material for the gang for ½ day without returning to the storehouse.

We have made it a point to keep the surface-treated gravel streets in good repair. This makes the fourth year that we have experimented with tar on gravel and have secured from that experience somewhat of an idea of the maintenance required to keep them in repair. We have been able to figure an average cost for this type of pavement covering a period of 4 years as follows:

	Per sq. yd.
Cost of gravel resurface	$0.400
Initial treatment of ½ gal	.090
Maintenance first year	.008
Second treatment of ¼ gal	.058
Maintenance second year	.003
Maintenance third year	.003
Maintenance fourth year	.003
Interest on investment at 5 per cent	.100
Total amount spent in 4 years, per sq. yd	$0.665

This does not include any profit, overhead or wear on tools.

Points That Should Be Observed.—Our four years of experience with surface treated gravel has taught us to observe the following points:

Not to apply the bituminous treatment on a gravel surface which is damp or dusty, as it will not incorporate itself with the pavement and will soon break out.

Be sure to apply the treatment uniformly the full width of the street, otherwise it will ravel at the edges.

To have the surface firm and smooth before applying the binder.

Not to apply the binder on any street which has not an adequate foundation, as the binder will not furnish that.

Not to apply the binder on any street unless the treatments will be kept up when they are needed. It has been found here that ½ gal. per square yard the first year with ½ gal, per square yard the second year, will keep the surface in such shape that no treatments will be necessary for two years. To put one treatment on a gravel street and then leave it alone will make it worse than if no treatments had been applied.

To give the pavements intelligent maintenance.

We have also observed that after the second treatment, the maintenance is no greater than on surface-treated macadam streets.

And that if they are handled rightly, the demand for them on light traffic streets is as much as our forces can conveniently supply.

COST OF RESURFACING OLD MACADAM WITH ASPHALT.—James A. McElroy, City Engineer, Bridgeport, Conn., gave the following in Roads and Streets:

Old waterbound macadam streets, dilapidated by modern traffic, are being converted into excellently surfaced thoroughfares in Bridgeport, by covering them with asphalt macadam. Not including overhead, the cost in 1922 of 140,000 sq. yd. of 3-in. surfacing was 87.1 ct. a sq. yd.; and in 1923 with higher wages and prices, the cost of 121,000 sq. yd. was 92 ct. a sq. yd. These low costs were obtained by a combination of contract and day labor which also has given rather excellent progress, the work of 1922 having been done in 140 days, and in 1923 in 130 days—an average of 1,000 sq. yd. a day.

Cost Figures.—At the beginning of operations in 1922 careful plans were formulated for doing the work by a sequence of crews each performing a particular task. These plans were improved and continued in 1923. That year three crews have done the work for which four were employed in 1922, and also the size of some of the crews has been reduced. It is this reduction of force which has enabled costs in 1923, despite higher wages and prices, to be kept about as low as in 1922 for which detail figures are given in Table I.

TABLE I

Penetration Pavement at Bridgeport

Year	1922	1923
Grading	$0.072	$0.067
Extra stone in base	.064	.072
Surface stone	.290	.351
Asphalt	.330	.311
Surface labor	.087	.111
Undistributed	.028	.005
Total, per sq. yd.	$0.871	$0.917

	1922	1923
Labor (per hr.)	$0.35	$0.45
1½ in. stone (per cu. yd.)	2.55*	3.00*
¾ in. stone (per cu. yd.)	2.65*	3.10*
½ in. stone (per cu. yd.)	2.65*	3.35*
Asphalt (per gal.)	.14†	.129†

*Delivered. †Applied.

Quantities Used.

1½ in. stone	3 in. thick
¾ in. stone	20 per cent of 1½ in. stone
½ in. stone	1/70 cu. yd. per sq. yd.
Asphalt base	1½ to 1¾ gal. per sq. yd.
Seal	¾ gal. per sq. yd.

In all figures the costs of stone and asphalt are contract prices for these materials in place. The difference in price and quantity of asphalt per square yard are in a considerable measure due to difference in the amount of stone per square yard required to bring the old street to surface. In general the old macadam was badly worn and full of pot holes. Its only usefulness was as a base.

Methods of Handling the Work.—Reconstruction consisted of four principal processes,—grading, placing stone, asphalting and finishing, which in 1922 were conducted as follows:

After the engineers had established the new grades the first crew to enter the street was made up of one foreman, about ten men and a steam roller equipped with a scarifier. The street was scarified and reshaped, some of the surplus material being used to fill in the low places. Where the foundation was poor, new stone was added and the whole street rerolled and left in shape 3 in. below the new grade. The finished crown was ¾ to 1 in. to the foot. With a season's experience it was possible this year to reduce the grading gang by two men. This reduction was aided by the plan of not scarifying the center of the old macadam but was chiefly due to greater skill of the foreman following a year's experience.

The second gang, consisting of one foreman and six men, followed with the stone. The stone, trap rock, was unloaded from a barge by a clamshell bucket directly into a hopper, from which it was loaded into trucks. When a truck arrived on the street the tail gate was chained so that it would open about 6 in. The truck would start as soon as the load was hoisted, and in this way the stone was fairly evenly spread; men with forks corrected any unevennesses. The stone then was rolled by another roller which remained with this crew.

Any low places were brought to grade by one or two men who were placed behind the spreaders. As soon as the stone was ready this gang went ahead to the next street which by this time had been prepared by the grading gang.

Applying Asphalt.—The third gang was made up of a foreman and ten men, equipped with a steam roller and one of the new distributors. Asphalt heated in tank cars at the city yard was applied by this gang at the rate of about 1¾ gal. to the sq. yd. Three-quarter and ½ in. stone had been placed in piles on both sides of the street about 25 ft. apart, the pile on each side alternating. As soon as the asphalt was applied the ¾ in. stone was spread and rolled. When the stone was thoroughly rolled a second application of about ¾ gal. of asphalt was applied and covered with the ½ in. stone. To keep up the speed of the work it was necessary some days, particularly after a wet spell, to apply 6,000 to 8,000 gal. of asphalt a day.

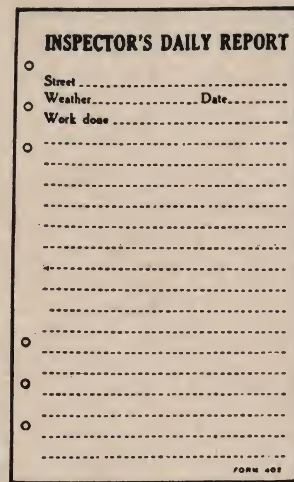
In 1922 a fourth crew consisting of three men and a team, was employed to touch up places not thoroughly covered, and to clean up the surplus material, but in 1923 this finishing was made a part of the work of gang three.

A DAILY REPORT SYSTEM FOR ASPHALT PAVING INSPECTION.—Engineers charged with the responsibility for the construction of public work many times find themselves unable, because of various inroads on their time, to visit the individual jobs as frequently as the work really requires. This means either neglect of the work or the installation of some system of "distant control" as an electrical engineer would term it. Fortunately a very complete system of such control requires only a small expenditure of time, energy or money; in fact, a well devised and strictly enforced system of "daily reports" properly used will satisfy all demands. For past years the Bureau of Engineering of Binghamton, N. Y., has been using a system of daily reports in connection with its construction work. The following brief description of the system as applied to asphalt construction has been prepared by the city engineer of Binghamton, and published by the Asphalt Association in a circular:

The daily report has long been the ever-present help of engineers occupying executive positions in private corporations, but the tendency, unfortunately, in public work has been to dismiss the report as a useless bit of red tape. In reality a system of daily reports has three distinct values. First—The necessity of preparing a daily report that will be read has a decided effect in holding an inspector closer to his job. Second—When the work is complete the daily reports form an invaluable record of the job. The profession of contracting has its share of constituent members having such common human failings as inefficiency and dishonesty. Sooner or later every engineer will meet a contractor endowed with one or both of these failings. At such a time the record comes into its own and demonstrates its worth. Third—Daily reports, received and considered not later than the morning of the day following the one covered by the report, keep the engineer in touch with the work each day, no matter how the individual jobs may be scattered, thus making it possible for him to follow the progress of the work, to check the ability of his inspectors and to determine just where the time at his disposal for visiting the work shall be spent. This last is "distant control."

No type of construction work lends itself so readily to such control as the asphalt pavement and municipal engineers who have spent weary hours either searching for or trying to develop capable asphalt inspectors will add, perhaps, that no type of construction work stands so much in need of such control.

Inspection of Asphalt Plant.—Whenever asphalt work is in progress in Binghamton at least one inspector is on duty at the plant. This inspector is required to file a daily report including certain specific and certain general information regarding the day's run. For instance, he is required to take at hourly intervals the temperature of the asphaltic cement in the melting kettles and to note these temperatures in his report. He also notes on his initial report the mixing formula used by the contractor and on subsequent reports indicates any change in this formula. Two other items of specific information must be furnished by the plant inspector on each daily report, the total run of the plant in tons and a statement of all materials received. He is at liberty, in fact is encouraged, to report any item of general interest in regard to the plant operation, such as the force employed, accidents to employes or to the plant and general observations concerning operating efficiency. He must report back to the office on his daily report any orders which he may have received during the day. This feature of the report has been especially valuable both in fixing responsibility and in assuring the engineer in charge that his instructions are understood. All this information is recorded on Form 402


INSPECTOR'S DAILY REPORT

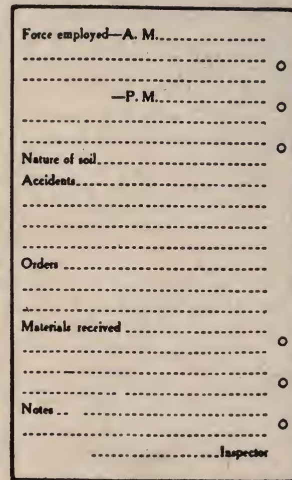
Street

Weather Date

Work done

FORM 402

Fig. 1—Front of Sheet.


Force employed—A. M.

—P. M.

Nature of soil

Accidents

Orders

Materials received

Notes

Inspector

Fig. 2—Back of Sheet.

(see Figs. 1 and 2). This report must be filed in the city engineer's office not later than 9 o'clock in the morning of the following day. In addition to the things the plant inspector must do in order to render a satisfactory report he also takes samples of all materials received and makes such simple plant tests as may be required to keep the mix fairly uniform. At times it has been found advisable to have two inspectors at the plant, one spending all his time on the mixing platform. The samples taken by the inspector include a daily sample of the asphaltic cement taken the first thing each morning from the kettles.

Every load of "mix" leaving the plant must be accompanied by a consecutively numbered load report (see Fig. 3) signed by the plant inspector. These reports are made in triplicate by the inspector who notes thereon the number, destination, temperature and weight of the load and the time it left the plant. One of these reports is given to the driver of the truck or wagon, the second is given to the plant foreman and the third is retained by the inspector. When the load arrives on the street the driver must deliver to the city inspector on the street his copy of the load report. The temperature of the mix is again taken and, if this temperature is satisfactory, the load is dumped. The inspector then notes on the copy of the load report given him by the driver the temperature as determined on the street, the time the load was received and roughly the number of square yards the load was made to cover. The plant inspector sends his copies of the load reports to the office with his daily report and the street inspector does the same with the copies that he has received from the drivers.

Street Inspection.—The street inspector is required to submit a daily report covering the work done, the force employed and the materials received on the job. The work done must be so described that, should it be necessary, the work of any half day can be located both on the street and in the plant reports. This result is obtained by describing the work by stations which have been chalked on the curb at regular and frequent intervals by the engineer in charge and by designating by load numbers the mix used in each section. The street inspector is also required to show on his report a fairly close estimate of the yardage of top placed during each half day and to give, as in the case of the plant inspector, a brief synopsis of any and all orders that he may receive. He is also required to take at least two samples each day of the mixture as received on the street and to indicate very carefully the exact locations in the street and the number of the loads from

which these samples were taken. The daily reports of the street inspector must be filed in the city engineer's office not later than 9 o'clock of the morning following the day covered by that report.

ASPHALT MIX "LOAD" REPORT

Street .... Date ....
Driver .... Load No. ....
Temp. at plant .... Temp. on street ....
Time left plant .... Time received on street
Weight .... Sq. Yards ....

ASPHALT MIX "LOAD" REPORT

Street .... Date ....
Driver .... Load No. ....
Temp. at plant .... Temp. on street ....
Time left plant .... Time received on street ....
Weight .... Sq. Yards ....

ASPHALT MIX "LOAD" REPORT

Street .... Date ....
Driver .... Load No. ....
Temp. at plant .... Temp. on street ....
Time left plant .... Time received on street
Weight .... Sq. Yards ....

FORM 405

Fig. 3—Load Report Form

Asphalt "Laboratory" Report

STREET ....
Date .... No. ....
Sample taken from ....

ASPHALTIC CEMENT

Ductility ....
Volatilization ....
Penetration of residue ....
Percentage lost ....
Penetration ....

SURFACE MIXTURE

Bitumen soluble in carbon disulphide ....
Aggregate
Passing No. 2—Retained on No. 4 ....
Passing No. 4—Retained on No. 10 ....
Passing No. 10—Retained on No. 40 ....
Passing No. 40—Retained on No. 80 ....
Passing No. 80—Retained on No. 200 ....
Passing No. 200 ....
Total ....
(Signed) ....

FORM 403

Fig. 4—Laboratory Report Form

The samples of the asphaltic cement and of the surface mixture as taken by the inspector are delivered by the engineer in charge of the work to the city chemist for analysis. These analyses are made immediately and the results reported to the city engineer on the "Asphalt Laboratory Report" (see Fig. 4).

Handling the Reports in the Office.—In the office the load reports from the plant are checked against the load reports from the street and then destroyed. The load reports from the street are then considered, temperatures being noted first. Any load leaving the plant too hot or received on the street too cold is listed for comment. The tonnage for the day is compiled next and checked against the daily report of the inspector at the plant. Any discrepancy calls for an explanation. The tonnage of mix used is then divided by the total yardage reported by the street inspector on his daily report. The result must at least be equal to a previously determined weight per square yard. A discrepancy in this results in a "riot call" for contractor, inspectors and engineer-in-charge and just must be explained or rectified. The recorded temperatures of the asphaltic cement are rapidly considered for any evidence of overheating and the laboratory reports checked over as to grading of mix and amount and quality of asphaltic cement. These things can all be done by the secretary if the city engineer or the deputy engineer are busy and only the variations noted. The remainder of the daily reports are read very carefully and any job that seems to need personal attention is visited during the afternoon.

The Report Forms.—All of the forms used for the above reports are uniform in size and as simple and convenient as possible. This uniformity of size is applied to specifications, extra work orders and extra work reports, thus making it possible for the inspector to keep all his data and reports between the covers of a single binder. All forms are made 3¾ in. x 6¾ in. in size—a real pocket size—and are punched for use in ring binders. Field reports are printed on pale blue and laboratory reports on a light orange paper. When the job is complete all daily reports, field notes, written orders, extra work reports, construction records and estimates are bound together in an inexpensive binder and filed away to form the office history of the job. It is surprising how many times these "histories" are needed for reference.

Attention is called to the fact that the system above described is not academic but rather is eminently practical and that it has stood the test of several years' exacting use without any serious change in the system or in the form. It is not to be understood that this system will supply ability that may be lacking in inspectors. No report can possibly tell how well the requirements of the specifications as to handling material or as to raking are carried out. The system will, however, from its very nature tend to increase the inspector's interest in and application to his job. It is sometimes objected that such a system requires too much time. This objection may be met with a flat denial. Finally it must be noted that the ultimate success of the system depends upon the engineer himself. If the reports are dismissed with a careless, cursory glance at least a third of the value of the system is absolutely wasted.

Bituminous Pavement Cost Data

Cost of Tarvia Treatment at Queen Victoria, Niagara Falls, Park System.—The following data relate to surface treatment on the Niagara River Boulevard in the Queen Victoria Niagara Falls Park System, Ontario. The average haul was 1½ miles, and the surface treated was 18 ft. wide and 14,000 ft. long. About ¼ gal. of Tarvia was applied per square yard of surface. The detailed cost of treatment follows:

Labor	Cts. per sq. yd.
Teaming, ½-in. stone	1.38
Loading and spreading stone	1.12
Sweeping and brushing roadway	.20
Heating tarvia	.80
Distributing and rolling	.20
Miscellaneous	.18
Total labor	3.88
Materials:	
½-in. stone chips, 348 tons at $2.60	3.24
Tarvia A, 6,500 gal. at 10 cts.	2.32
Freight, $115; car service, $19	.48
Coal, 19.7 tons at $10.00	.70
Total materials	6.74
Grand total	10.62

The above figures are on the basis of wages for teams at 90 cts. per hour; laborers at 40 cts. per hour and foremen, 65 cts.

Data on Asphaltic Concrete Surface.—The following data are taken from an abstract published in *Engineering and Contracting*, of a paper by R. Crawford Muir presented at an annual conference of Ontario Road Superintendents:

Mr. Muir described the reconstruction of Dundas Street which is the chief means of access to Toronto.

The wearing surface mixture was prepared in a 1-car portable paving plant of 2,000 sq. yd. of 2-in. top per day (10 hours) rated capacity, having a twin-pug mill (10 cu. ft.) capable of handling a 1,000-lb. batch of material. The total weight of this plant ready for transporting is 100 tons.

When the plant is working at its full capacity, 3 tons of coal are required per day.

The organization at the plant was as follows:

1 Foreman.
1 Engineer.
1 Fireman and 1 blacksmith.
2 Men at scales weighing materials.
2 Men feeding stone to elevator to drier.
2 Men feeding sand to elevator to drier.
2 Men shoveling stone from car.
2 Men shoveling sand from car.
2 Men stripping barrels, etc.
1 Man with horse conveying stone from car to elevator.
1 Man with horse, conveying sand from pile to elevator.

On a good day's work (8 hours) the following quantities of material were used: 16 tons of asphalt, 132 tons of stone, 47 tons of sand, 11 tons of dust or filler, making a total of 206 tons of mixture.

The materials were mixed in a batch as follows:

	Weight, lb.	Per cent
Stone (½-in.)	625	64.10
Sand	225	23.07
Dust (filler)	50	5.13
Asphalt cement	75	7.70
Total	975	100.00

These weights, of course, were modified from time to time, in order to take care of the variations in the materials as delivered. Special care was exercised to see that there was always a high percentage of filler and that the mix carried all the asphalt cement possible without being sloppy.

When the quantity of asphalt cement in the mixture exceeded 7¾ per cent of the total weight there was trouble in some places with waving and ridges in the pavement, also with more or less bleeding. On the other hand, if the percentage fell below 7, the pavement had a tendency to crack.

The hot mixture was hauled from a portable plant, which was located at a railway station, to the road in the usual asphalt spreading wagons, dumped on the foundation at a temperature varying from 250° to 350° F. and conveyed to its final resting place by means of shovels. In shoveling the hot mixture into place, the material was shoveled from the bottom of the pile, thereby preventing the lower layer of the pile becoming chilled. When the lower part of the pile becomes chilled, an uneven distribution and compression results. On a number of loads, especially on a long haul the larger particles of the mixture settled to the bottom of the load; when this occurred, the mixture on being dumped was remixed by turning over with hot shovels. The mixture, after having been deposited roughly in place by shovels, was spread by means of hot iron rakes to a depth of 2¾ in., thus allowing for an ultimate compression of 2 in. During this operation the rakers did not stand on the hot mixture any more than was necessary. Care was taken that all lumps were broken and a uniform consistency and even grade maintained, so as not to have depressions in the finished pavement. Raking is a most important factor in the construction of an asphaltic concrete pavement. With a hot mixture, 300° F. or more, 4 to 6 minutes were necessary for raking, but with a cold or stiff mixture 10 to 20 minutes were sometimes required. Cold or extra stiff mixtures should be avoided as insufficient compression and inconsistency results.

The largest number of loads dumped in one day was 65 (228 tons), covering an area of 1,800 sq. yd. or a length of 940 lin. ft. This was on the shortest haul, ⅛ of a mile. On the longest haul, 2 miles, 36 loads (126 tons) were dumped, 9 teams each making 4 trips in 8 hours, covering an area of approximately 1,130 sq. yd. On an average of a full day's work, 46 loads (106 tons) were deposited on the road, covering an area of approximately 1,300 sq. yd. These quantities would have been increased had the contractor placed more teams on the work.

Cost of Asphaltic Macadam.—The following data relate to street improvements at Waynesboro, Pa., carried out by the city street force under the supervision of the city engineer.

The organization consisted of two foremen at 80 cts. per hour, a roller operator at 75 cts. per hour and labor at 50 cts. per hour.

Of the 25,000 sq. yd. of asphaltic pavements laid, one block (1,170 sq. yd.) was constructed on Cleveland Ave., the cost of which follows:

It was found upon examination that the old macadam was so badly worn that an entire new base was necessary, and in order to bring the contour of the road to its proper place, about 8 in. of grading had to be done, the rough grading being handled by means of the road roller and plow. The average haul was 1 mile.

Upon the thoroughly rolled sub-base, run of crusher limestone 6 in. thick (after compression with a 10-ton roller) was used as a base.

Three inches of crushed stone (after compression) 2 to 3 in. in size was placed upon this base and after being thoroughly rolled with a 10-ton roller the asphalt, was applied by means of pouring cans. Just enough ¾-in. stone to take up the voids was then spread over the hot asphalt and the whole was again thoroughly rolled. After applying ½ gal. of asphalt per square yard, the surface was covered with ½-in. chips and rolled.

The ¾-in. and ½-in. stone contained a great deal of dust and screening was necessary before they could be applied to the road. The cost of the work was $1.92 per square yard, as follows:

Grading (312 cu. yd.)

Unit	Amount	Rate	Per sq. yd.
Teams	122 hr.	$0.90	$0.0938
Labor	50 hr.	.50	.0214
Labor	332½ hr.	.40	.1137
Roller engineer	21 hr.	.75	.0132
Insurance ($1.74 per $1,000)	....	....	.0020
Supervision	....	....	.0230
Coal	2,465 lb.	7.00	.0075
Oil	1 gal.	1.00	.0008
Dep. machinery	....	....	.0358
Total ($1.17 per. cu. yd.)			$0.3112

Macadam Base, 6 in. (1,170 sq. yd.)

Unit	Amount	Rate	Per sq. yd.
Stone	250 tons	$2.50	$0.5350
Hauling	99 hr.	.90	.0761
Spreading	108 hr.	.50	.0432
Rolling	7 hr.	.75	.0045
Coal	828 lb.	7.00	.0023
Oil	¼ gal.	....	.0002
Supervision	....	....	.0110
Insurance	....	....	.0007
Dep. Machinery	....	....	.0120
Total			$0.6850

Asphalt Surface, 3 in. Stone (1,170 sq. yd.)

Unit	Amount	Rate	Per sq. yd.
Stone (2 in. and 3 in.)	164 tons	$2.50	$0.3510
Hauling	65 hr.	.90	.0504
Spreading	116 hr.	.50	.0465
Rolling	11 hr.	.75	.0069
Coal	1,291 lb.	....	.0037
Oil	½ gal.	....	.0004
Supervision	....	....	.0190
Insurance	....	....	.0009
Dep. Machinery	....	....	.0188
Total			$0.4976

Asphalt

Unit	Amount	Rate	Per sq. yd.
Asphalt	2,381 gal.	$0.08½	$0.1729
Hauling	37 hr.	....	.0131
Applying	128 hr.	.50	.0510
Wood	3 cords	8.00	.0206
Oil and waste (12-gal. oil)	....	....	.0030
Supervision	....	....	.0050
Insurance	....	....	.0009
Dep. machinery	....	....	.0052
Total			$0.2717

Stone, 1 in. and ¾ in.

Unit	Amount	Rate	Per sq. yd.
Stone	15 tons	$2.50	$0.0320
Hauling	13 hr.	.90	.0101
Spreading	17 hr.	.50	.0067
Screening	23 hr.	.40	.0078
Rolling	4 hr.	.75	.0027
Coal and oil	....	....	.0014
Supervision	....	....	.0055
Insurance	....	....	.0005
Dep. machinery	....	....	.0068
Total			$0.0737

Stone, ½ in.

Unit	Amount	Rate	Per sq. yd.
Stone	6 tons	$2.50	$0.0127
Hauling	7 hr.	.90	.0054
Spreading	11 hr.	.50	.0045
Screening	11 hr.	.40	.0038
Rolling	4 hr.	.75	.0027
Coal and oil	468 lb.	....	.0014
Supervision	....	....	.0055
Insurance	....	....	.0002
Dep. machinery	....	....	.0068
Total			$0.0430

Miscellaneous

Unit	Amount	Rate	Per sq. yd.
Teams	21 hr.	$0.90	$0.0160
Labor	49 hr.	....	.0158
Blacksmith, repairs, etc	....	....	.0026
Total			$0.0344

Summary

	Per sq. yd. pavement
Grading	$0.3112
Base	.6850
3-in. surface	.4976
Asphalt application	.2717
Stone, 1-in. and ¾-in.	.0735
Stone, ½-in.	.0430
Miscellaneous	.0344
Total	$1.9164

Cost of Removing an Asphaltic Macadam Road Surface, Reworking the Old Material and Relaying It as Asphaltic Concrete.

A poured process asphaltic macadam surface 16 ft. wide was laid on a trunk line road subject to a heavy traffic. Holes began to appear in the surface after its completion.

Removing Old Surface.—The asphaltic surface to be removed was first swept clean. Twelve men, picking, lifted and picked into small chunks and shoveled into wheelbarrows, the material covering about 250 lin. ft. of roadway surface each day.

In scalping off the old bituminous top, two places were broken up at the same time to hasten the work. At first the men picking stood on the surface already broken up, pulling the chunks as picked up, toward them. This did not work out satisfactorily so another method was tried, in which the men stood on the old surface, driving the pick beneath the broken edge. The surface coat was then readily lifted and broken into pieces that could be handled. These large pieces were then thrown back where three men picked them into still smaller ones to save time in the mixers. The old material broke up readily in the morning but towards noon softened and more time was needed in breaking. Although the depth of penetration was far from being uniform, the bituminous top separated readily from the slag foundation.

Long stretches of the old surface were laid when the foundation was wet, and the bad effects of water present could be seen. The asphalt had not penetrated to a sufficient depth, and there was practically no bond in the pavement in such places. In other places a 6-in. penetration was observed. When the old surface was broken up the stone was often covered with moisture and the asphalt could be peeled from the stone. This presence of moisture may be partially accounted for in that the general drainage of the road was poor, yet it is probable that the foundation had not been in a dry condition since the pavement was laid. When the road was resurfaced, the foundation was allowed to dry out and the general drainage was also taken care of.

Mixing and Placing.—The equipment for mixing and placing consisted of 2½-cu. yd. hot mixers, 1 (500-gal.) heating kettle, 1 (5-ton) roller, carts, small tools, etc.

The old surface picked into small chunks was delivered to the mixers in wheelbarrows. An average batch consisted of sufficient material to lay 3½ sq. yds. of 2½ in. asphaltic concrete surface, and contained 728 lbs. of old top, 252 lbs. of new stone and 15.92 lbs. of new asphalt.

The old top was charged into the mixer with about 25 per cent of ½ to ¾-in. stone added and about 0.45 gals. per square yard, or about 1.6 gals. per batch, of

new asphalt. Mixing was usually continued 8 mins. at the end of which time the temperature of the material would average about 240° F. Two high-wheeled carts were used to convey each batch to the point where it was to be laid.

The base, after removing the surface materials, was found to be very rough due to the original poor grading, and to the varying depths of penetration of the asphalt. All depressions in the bottom layer were filled with ¾-in. stone, after which it was thoroughly compacted by rolling.

After the material had been laid and rolled to a thickness of 2½ ins., a squeegee coat of asphalt was applied at the rate of about 1 gal. per square yard. A ¼ in. layer of stone chips free from dust, was then put on and rolled in. It was believed that ½ gal. of asphalt per square yard would be sufficient for the squeegee, but due to the large size stone in the old surface material, it was necessary to double this quantity.

Each day a sample of the surfacing laid was analyzed by the chemist and from the results of his analysis, together with the appearance of the old material, the mix was determined. Almost constant attention had to be given the mix on account of the varying composition of the materials. An attempt was made to keep the per cent of bitumen between 5 and 6, but it was low at times due to the large stones in the sample tested.

The road was opened to traffic about an hour after completion. Thirty-eight men were required 24 working days to tear up, remix and relay 9,055 sq. yds. In a 10-hour day a maximum of 510 sq. yds. was laid.

Cost and Personnel.—Below is an itemized statement of the costs per square yard of pavement laid. These figures were compiled from the daily expenses as gathered by the state inspector and are very close to the exact cost.

The prevailing rate of wages are $4.00 a 10-hr. day for ordinary labor; $6.50 and $7.00 being paid enginemen, firemen and rollermen, and $6.00 for raker. The teams cost $9.00 per day.

The estimate for foreman is based on 30 days at $15.00. The contractors had two foremen on the work at all times, both being members of the contracting firm.

The equipment cost cannot be stated in exact figures, since it was owned by the contractor, but the figures given represent an average rental price.

Unit Costs of Work

		Cost per sq. yd.
Labor:		
Preparing old bituminous top—		
2 enginemen	$0.037	
2 firemen	.033	
2 platform men	.026	
6 wheelers	.058	
12 pickers	.128	
Total		$0.282
Placing new material—		
4 cartmen	$0.040	
1 kettleman	.016	
1 raker	.021	
1 rollerman	.019	
Total		$0.096
Preparing grade—		
3 grademan		$0.039
Putting on squeegee and chips—		
3 squeegeemen		.037
Other labor—		
2 helpers	$0.021	
1 waterboy	.006	
1 nightwatchman	.013	
Incidental labor	.028	
Team (steady)	.031	
Total		$0.099
Cost of labor, per sq. yd.		$0.553
Materials:		
Asphalt—		
20.53 tons in mix	$0.051	
49.80 tons in squeegee	.123	
Cost of asphalt per sq. yd.		$0.174
Stone—		
325.9 tons in mix	$0.226	
90.5 tons in chips	.038	
12.7 tons in grade	.010	
Cost of stone per sq. yd.		$0.274
Incidentals—		
Fuel, insurance, freight on equipment, etc.		$0.146
Equipment (estimated)—		
Roller and kettle	$0.046	
Two mixers	.200	
Small tools	.012	
Total		$0.258
Foreman (estimated)		$0.050
Grand total		$1.455

Summary Item	For 2,586 Batches Average per batch	Totals
Length surfaced, lin. ft.	1.97	....
Area surfaced, sq. yd.	3.50	9,046.5
New asphalt added, lbs.	15.92	41,065
New asphalt added, per cent	1.6	....
Old bitu. top, lbs.	128	1,882,835
Old bitu. top, per cent	73.1	....
New stone in mix, lb.	252	651,790
New stone in mix, per cent	24.3	....

DETAILED COST OF SHEET ASPHALT PAVEMENT AT FLINT, MICH.—The city of Flint, Mich., operates a municipal asphalt plant for both construction and repair of streets. The following average detailed costs of operation were given in Roads and Streets and also the cost of a sheet asphalt job at 382 Ida Ave., from Corunna Road to Miller Road.

Cost of Patch Work.—The following short account shows the average cost of making repairs in the city. This includes cutting out the patch and hauling away the old material.

Repair and Patch Work

	Per Sq. Yd.
Plant:	
Labor, supplies, repairs and depreciation	$1.40
Hauling	.06
Material—asphalt, binder stone, dust, sand	.49
Street:	
Labor, supplies, tools, rolling, moving	4.45
Laboratory and supervision	.10
Total per square yard	$6.50

AVERAGE DETAILED ASPHALT COSTS PER SQUARE YARD FOR YEAR

Construction

1½ in. Binder—1½ in. Top

		Cost per Sq. Yd.
Plant:		
Plant labor—foreman, 11 men	$0.08	
Crane and supplies	.03	
Supplies—coal, grease, fuel oil, oil, power, lights, water, etc.	.115	
Plant repairs and depreciation	.20	
		$0.425
Hauling:		
Asphalt hauled from central plant to various streets	$0.06	
Material:		
Asphalt (tank cars)	$0.20	
Binder stone	.10	
Dust	.09	
Asphalt sand	.10	
		$0.49

Street:	
Street labor—foreman, 15 men	$0.09
Supplies—grease, oil, kerosene, etc.	.01
Tools, etc.	.005
Rollers	.02
	$0.125
Laboratory and supervision	$0.10
Total per square yard	$1.20

Asphalt Labor Rates and Hours

		Hours per day
Street:		
1 Foreman at	$ 55.00 per week	10
2 Roller operators at	45.00 per week	10
5 Rakers at	.70 per hour	10
3 Tampers at	.60 per hour	10
4 Shovelers at	.55 per hour	10
1 Laborer at	.50 per hour	10
Plant:		
1 Foreman at	$ 0.75 per hour	10 to 15
3 Mechanics and operators at	.75 per hour	10 to 15
1 Drum fireman at	.60 per hour	10
1 Night fireman at	.55 per hour	12
3 Laborers at	.60 per hour	10
3 Laborers at	.50 per hour	10
Superintendent	75.00 per week	
Chemist	225.00 per month	
Hauling, 5-ton trucks at	2.50 per hour	

Weights of Material per Box or Batch and Prices

Binder, 1½ in.		Top, 1½ in.		Price per Ton	
Stone	1,000 lb.	Sand	1,150 lb.	A. C.*	$20.50
A. C.	70 lb.	Dust	350 lb.	Dust†	5.65
Sand	350 lb.	A. C.	145 lb.	Sand	1.32
				Stone	2.10
Approx.	1,420 lb.	Approx.	1,645 lb.		

COST OF SHEET ASPHALT PAVEMENT, 382 IDA AVE., CORUNNA RD. TO MILLER RD. STARTED 8/3/26; COMPLETED 8/6/26

Labor:	
Plant labor was 365.5 hours at	$ 232.40
Street labor was 407.5 hours at	261.45
	$ 493.85
Material:	
Asphalt, stone, sand, dust	$1,429.21
Plant Expense:	
Crane and supplies	$ 87.15
Supplies	334.07
	$ 421.22
Street Expense:	
Supplies—Tools, etc.	$ 29.05
2 Rollers—Total 47 hours, at $1.50 per hour	70.50
	$ 99.55
Hauling:	
Trucks—Total 68 hours at $2.50 per hour	$ 170.00
Supervision and laboratory	290.50
Plant repair and depreciation	581.00
Total cost (2,905 sq. yd. of binder and 2,905 sq. yd. top)	$3,485.83

*In tank car. †In bags.

Cost of Asphalt Pavement, New York.—In the following tabulation is given the labor cost to the contractor of laying 8,900 sq. yds. of asphalt pavement on Broadway, from 110th street to 119th street, west side, New York. The wages paid were on the basis of an 8-hr. day:

1 in. Binder:	
0.0004 day foreman, at $9.00	$0.0036
0.0008 day rollerman, at $8.00	.0064
0.0063 day labor, spreading, at $6.00	.0377
0.0009 day labor, ramming at $6.50	.0058
Total binder, per sq. yd.	$0.0535
1½ in. Wearing Surface:	
0.0005 day foreman, at $9.00	$0.0045
0.0040 day laborers, at $6.00	.0240
0.0010 day rollerman, at $8.00	.0080
0.0070 day labor, spreading, at $6.00	.0412
0.0008 day labor, raking, at $7.00	.0056
0.0009 day labor, ramming, at $6.50	.0058
0.0016 day labor, ironing, at $6.50	.0104
Total surface coat, per sq. yd.	$0.0995

The binder was 1 in. thick, and the surface coat was 1½ ins. thick, making a total of 2½ ins. of asphalt. It will be seen that the laying cost of laying this asphalt was 5.35 cts. + 9.95 cts. = 15.3 cts. per sq. yd.

Cost of Excavating an Asphalt Pavement and Its Concrete Base.—In relaying a street car track it was necessary to excavate the pavement between the rails, and for two feet outside the rails. The pavement was asphalt 2½ ins. thick laid on a concrete base 9 ins. thick. The concrete was made with natural cement and was consequently by no means as difficult to excavate as it would have been if Portland cement had been used.

In taking up the asphalt between the tracks it was found that the progress depended very much upon the temperature of the day. On cool days when the asphalt was brittle and the men worked rapidly, it was possible for three men to excavate 3,840 sq. ft. between the tracks in 8 hours. This is equivalent to nearly 143 sq. yds. per man per day. Of course, it was not necessary to cut the asphalt loose from the rails on each side, so the work consisted merely in prying up the asphalt with crow bars and breaking it with a sledge. Two men pried the asphalt up, while a third man used the sledge, and cast the pieces aside ready to be hauled away.

During most of the time, however, the asphalt was hot enough not to be brittle, and had to be cut up with a grub ax. In that case two men would pry up the asphalt, using picks, while the third man would cut off a strip 1½ ft. wide and as long as the distance between the tracks. Then he would cut this strip in two pieces with the grub ax. In the meantime the two men with the picks would be prying up some more of the asphalt. These three men worked very deliberately and averaged 1,360 sq. ft. per day. This is equivalent to 50.4 sq. yds., or 3.8 cu. yds. per man per day. Wages were $5.00, hence the cost of excavating the asphalt was 7.85 cts. per sq. yd., or 71.5 cts. per cu. yd. This does not include the cost of loading and hauling it away.

In excavating the strip 1 ft. wide outside the rails, it was, of course, necessary to cut through the asphalt along a line parallel with the rail and 1 ft. away. To do this cutting a chisel having a bit 3 ins. wide and provided with a handle, was held by one man while a second man struck it with a sledge. These two men, when working rapidly, would cut 960 lin. ft. in 8 hours; hence one man cut 480 lin. ft., thus loosening 480 sq. ft. of asphalt ready to be pried up. A third man would pry up the asphalt with a pick and cut it off in sections, and he averaged 480 sq. ft. a day, working very deliberately. Hence the average output of each of the three men was 240 sq. ft., or 26⅔ sq. yds., per man per day, cut out, pried up, and cast aside. This is equivalent to a little more than 1.8 cu. yds. per man per day, and the cost was $2.78 per cu. yd., or $1.87 per sq. yd.

Cost of a Sheet Asphalt Pavement.—The pavement consists of a 6-in. 1:3:6 concrete base, a 1-in. binder and a 2-in. wearing surface and the work was done by city forces.

Six hundred thousand sq. yd. of sheet asphalt pavement were laid one year at the following cost:

Grading	Per sq. yd.
Foremen	$0.048
Timekeepers	.002
Engineers	.003
Layers	.009
Drillers	.001
Water boys	.001
Watchmen	.038

Laborers at 50 cts. per hour	.538
Teamsters	.350
Material	....
Sundries	.008
Repairs, int., etc.	.066
Total grading	$1.064

Concrete Foundation

Foremen	$0.032
Timekeepers	.002
Engineers	.013
Layers	.001
Watchmen	.038
Laborers	.233
Teamsters	.262
Autos	.001
Stone	.326
Sand	.301
Cement, at $1.71 per bbl.	.556
Sundries	.045
Repairs, int., etc.	.096
Total foundation	$0.906

Asphalt Surface

Foremen	$0.012
Timekeepers	.002
Engineers	.013
Spreaders	.028
Tampers	.016
Watchmen	.008
Laborers	.058
Teamsters	.014
Autos	.026
Material	....
Asp. bin. and wear	1.044
Sundries	.030
Repairs, etc.	.040
Total surface	$1.291

	Cost in Dollars per Sq. Yd. Grading	Foundation	Surface	Total
Labor	$0.990	$0.582	$0.177	$1.749
Material	....	1.183	1.044	2,227
Sundries	.074	.141	.070	.285
Total	$1.064	$1.906	$1.291	$4.261

The cost of material and the wages follows:

Bitumen—$21.50 per ton f. o. b. plant.

Sand—$1.35 to $1.50 per ton f. o. b. plant.

Stone—$1.80 to $2.00 per ton f. o. b. plant or works.

Stone dust—$11.00 per ton f. o. b. plant.

Flux—12 cts. per gal.

Cement—$1.71 per barrel f. o. b. plant or works.

Laborers—50 cts. per hour.

Teamsters—90 cts. per hour.

The detailed cost for the next year was—

	Cost in Dollars per Sq. Yd. Grading	Foundation	Surface	Total
Labor	$0.656	$0.539	$0.256	$1.453
Material	.013	1.068	1.132	2.232
Sundries	.076	.076	.029	.180
Total	$0.745	$1.683	$1.417	$3.865

The cost of material and wages follows:

Bitumen—$19.33 f. o. b. plant.

Sand—$1.35 to $1.50 f. o. b. cars or wharf.

Stone—$1.70 to $1.80 f. o. b. plant or works.

Stone dust—$9.80 f. o. b. plant.

Flux—11½ cts. f. o. b. plant per gal.

Cement—$1.76 f. o. b. plant or works per barrel.

Laborers—50 cts. per hour.

Teamsters—90 cts. per hour.

Cost of Operating at Municipal Asphalt Plant.—All minor repairs of asphalt pavements in the District of Columbia are made from the output of a portable municipal asphalt plant of 100,000 lb. per day capacity.

The following data on the work of the municipal asphalt plant for the fiscal year are taken from the report of the operations of the Engineer Department of the District of Columbia:

The following amounts of materials were purchased for use in manufacturing the output during the year:

Sand, 8,020.5 cu. yd. at	$ 1.32
Asphaltic cement, 1,101.8915 tons at	21.65
Limestone dust, 400 tons at	5.45

There was purchased for use in operating the mixer the following large items:

Fuel oil, 39,878 gal. at	$0.06439
Coal, 320.01 tons at	5.98
Wood, 50 cords at	14.805

The costs of operation, including material and labor, are kept from day to day and the summary of this data for the fiscal year develops the following unit costs for the year's operations:

Operation of Plant

Period of operation, 255¾ days; total output, 203,076 cu. ft.

	Cents per cu. ft.
At Plant:	
Labor	8.7
Fuel oil	1.3
Coal	0.93
Wood	0.18
Total	11.11
Haul from plant to street:	
Labor	6.66
On street:	
Labor	30.55
Painting joints	0.41
Wood	0.18
Total	31.14
Maintenance and repairs:	
At plant	0.58
On street	0.07
Total	0.65
Overhead:	

The original cost was amortized by deducting 20 per cent from same each year during the first five years of its life.

Supervision:	
Foremen and overseers	5.79
Total manufacturing costs per cu. ft.:	Cents
Plant, labor	11.11
Hot haul	6.66
Street work	31.14
Maintenance of plant and tools	.65
Supervision	5.79
Total cost	55.35

The sand used was bought under a contract at 80 cts. per cubic yard and hauled from the wharf to the plant at a cost of $4,156.14 for 8,020.5 cu. yd., or 52 cts. per cubic yard, a total of $1.32 per cubic yard. All other expendable material was delivered at the plant site at the costs used herein.

The cost of topping mixture was as follows:

94.21 lb. of sand at 80 cts. per cu. yd.; hauled, 52 cts. per cu. yd.	$0.05483
9.58 lb. limestone dust at $5.45 per ton	.02610
11.05 lb. asphaltic cement, at $21.65 per ton	.11961
Total material cost	$0.20054
Manufacturing and placing cost	.55350
Total cost per cu. ft.	$0.75404

The plant operating force consists of one foreman at $7.70 per diem and the following:

1 steam engineer at plant	$ 5.92
1 steam engineer at plant	5.04
1 fireman at plant	*4.00
1 timekeeper	4.48
1 skilled laborer	4.00
12 unskilled laborers	3.63

1 watchman	3.00
5 trucks (owned by D. C.)	†4.00
2 trucks, privately owned, each	10.80

The street placing force is as follows for each repair gang:

1 foreman, per annum	$1,680.00
2 rakers, per diem	4.08
3 tampers, per diem	4.08
3 shovellers, per diem	4.08
4 rollermen, per diem	4.08
4 laborers, per diem	3.08
1 2-ton truck, per diem	10.80
1 1½-ton truck, per diem	**4.00

*Acts as watchman in emergency.
†Per diem pay of driver.
**Without driver.

Each gang places an average of about 288 cubic feet per day. The number of street gangs varies with the seasonal and other controlling conditions up to the total capacity of the plant.

COST OF ASPHALTIC CONCRETE.—We are indebted to Mr. M. D. Wright, Director, Department of Public Works, Lynchburg, Va., for these itemized costs on Asphaltic Concrete Surface based on the average for 1927 construction on prepared base, i. e., on old rubble pavements after the necessary adjustments had been made and the rubble properly cleaned.

This plant operation record is for one 700 sq. yd. capacity Cummer Semi-Portable Asphalt Plant.

Plant Labor

Labor incident to mixing—			
(a) Plant running per 10-hr. day with 120 ton output:			
1 foreman at $4.00	$ 4.00		
1 fireman at 4.20	4.20		
1 fireman at 3.00	3.00		
1 fireman and night watchman at $3.60	3.60		
1 laborer at $3.00	3.00		
1 laborer at 2.75	2.75		
11 laborers at 2.50	27.50		
1 water boy at $1.25	1.25		
Total actual labor mixing		$49.30	
(b) Labor unloading material and general labor around plant during shut down for weather, repairs, etc., including average time lost per 10-hr. day run:			
1 foreman at $4.00	4.00		
1 fireman at 4.20	4.20		
1 watchman at 3.60	3.60		
9 laborers, 2 hrs. each, at 25 cts. per hr	4.50		
Total miscellaneous labor		16.30	
Total labor to produce 120 tons		$65.60	
Labor cost at plant per ton			$0.547

Materials

Materials used—			
(a) ½″ to 1¼″ stone	$ 1.15		
Freight	.76		
4% loss	.07¼		
65½%, or 1,300 lb., at	$ 1.98¼	$1.302	
(b) Sand (medium fine)	.65		
Freight	1.12½		
20% loss	.35½		
28%, or 560 lb., at	$ 2.13	.596	
(c) Paving cement	21.51		
.0½% loss	.11		
6½%, or 130 lb., at	$21.61	1.405	
Total cost per ton of material used			$3.303
Miscellaneous items—			
(a) Fuel at $5.14 per ton of coal for per ton of output		$0.235	
(b) Power at 2 cts. per Kw.-hr. for per ton output		.008	
(c) Unaccounted for		.147	
Total miscellaneous			.39
Total cost, per ton, at plant			$4.24

Actual cost of production at plant		$4.24

Hauling

Hauling to street: Average cost, per ton, to deliver, using 2-ton trucks at $1.50 per hr., amounts to 75 cts. per ton for first mile and 25 cts. per ton for each additional mile; with average haul of 1.8 miles		.95

Miscellaneous

Interest and depreciation on plant—		
1923 installation of 700 yd. plant	$15,000.00	
1924 addition to tipple	5,500.00	
1926 addition of boiler	1,000.00	
Total cost of plant	$21,500.00	
Estimated depreciation, including approximately $400.00 for repairs during current year	3,583.33	
6% interest on investment	1,290.00	
Total plant charge	$ 4,873.33	
Plant charge, per ton, for 3,688 tons as the 1927 production		1.32
Total cost, per ton, delivered on job		$6.51

Yardage

	Per Sq. Yd.
2⅝″ compressed thickness lays 6.988 sq. yds. per ton; therefore material delivered costs per sq. yd	$0.93

Street Labor

Installation or street charges based on average for 1927 construction—		
(a) All labor incident to spreading and finishing. Daily payroll—		
1 foreman at $6.00	$ 6.00	
4 mechanics (roller men, etc.) at $4.00	16.00	
2 laborers at $3.50	7.00	
4 laborers at 2.75	11.00	
18 laborers at 2.50	45.00	
Total daily payroll	$85.00	
	Cost Per Sq. Yd.	
94.4 sq. yds. per hr. at $8.50 per hr	$ 0.09	
(b) Material cost of seal coat, 4 gal. per sq. yd., at 14 cts. per gal.	.06	
(c) Material cost of chips, 10 lb. per sq. yd., at $2.11 per ton	.02	
(d) Equipment charge 2 rollers at $15.00 per day, 1 kettle at $5.00 per day, 700 sq. yds. per day at $35.00	.05	
Total street charges per sq. yd.		.22
Total actual cost in place, per sq. yd		$1.15

Summation

			Per Sq. Yd.
Actual cost or summation of all preceding items			$1.15
Supervision, inspections and overhead, 15%			.17
Total nominal cost of 2⅝″ asphaltic concrete surface in place, exclusive of cleaning or repairs to base			$1.32
All plant and equipment, except trucks being municipally owned, the following items do not appear on the Auditor's books:			
(1) Interest and depreciation listed above	$ 1.32		
Except repairs	.11		
		Per Sq. Yd.	
Not appearing per ton	$ 1.21 or	$0.17	
(2) Equipment charge on street		.05	
(3) Overhead charge of 15%, less actual engineering and inspection charge of 4% and miscellaneous 4%		.08	
Deduct all charges not appearing on books			.30
Net charges as shown by Auditor, per sq. yd			$1.02

Bituminous Treatments

KIND AND AMOUNT OF COVER FOR BITUMINOUS TREATMENT ON A WATERBOUND MACADAM SURFACE.

From a Bulletin Prepared by A. H. Hinkle for the Ohio State Highway Department

BITUMEN. Kind.	Gal. per sq. yd.	Size.*	Crushed stone. 2500 lbs. cu. yd. Tons per sq. yd.	Crushed stone. Lbs. per gal.	Gravel. 3000 lbs. cu. yd. Tons per sq. yd.	Gravel. Lbs. per gal.	Slag. 2000 lbs. cu. yd. Tons per sq. yd.	Slag. Lbs. per gal.	Sand. 2700 lbs. cu. yd. Tons per sq. yd.	Sand. Lbs. per gal.
Asphalt H. O. (s)	.5	No. 4 No. X	.0210	84	.0250	100	.0165	66	.....	.....
	.6	"	.0252	84	.0300	100	.0198	66	.....	.....
	.7	"	.0294	84	.0350	100	.0231	66	.....	.....
	.8	"	.0336	84	.0400	100	.0264	66	.....	.....
Asphalt H. O.	.5	No. 4 No. X	.0203	81	.0238	97	.0163	65	.....	.....
	.6	"	.0243	81	.0385	97	.0195	65	.....	.....
	.7	"	.0284	81	.0333	97	.0228	65	.....	.....
	.8	"	.0320	81	.0380	97	.0260	65	.....	.....
Asphalt A. C. B.	.4	No. 4	.0136	68	.0162	81	.0108	54	.....	.....
	.5	"	.0183	73	.0218	87	.0145	58	.....	.....
	.6	"	.0225	75	.0270	90	.0180	60	.....	.....
Asphalt C. O.	.2	No. 6 or S.T. Sand	0	0	0	0	0	0	0	0
	.3	"	0 to .0018	0 to 12	0 to .0023	0 to 15	0 to .0015	0 to 10	0 to .0020	0 to 13
	.4	"	0 to .0032	0 to 17	0 to .0040	0 to 20	0 to .0026	0 to 13	0 to .0035	0 to 18
	.5	"	0 to .0050	0 to 20	0 to .0060	0 to 24	0 to .0040	0 to 16	0 to .0053	0 to 21
Asphalt C. O. (s)	.3	No. 6 or S.T. Sand	0 to .0018	0 to 12	0 to .0023	0 to 15	0 to .0015	0 to 10	0 to .0020	0 to 13
	.4	"	0 to .0032	0 to 17	0 to .0040	0 to 20	0 to .0026	0 to 13	0 to .0036	0 to 18
	.5	"	0 to .0050	0 to 20	0 to .0060	0 to 24	0 to .0040	0 to 16	0 to .0053	0 to 20
Asphalt C. O. (t)	.4	No. 6	.0136	68	.0164	81	.0108	54	.....	.....
	.5	"	.0183	73	.0218	87	.0145	58	.....	.....
Asphalt C.O. (50)	.4	No. 6	.0126	63	.0150	75	.0100	50	.....	.....
	.5	No. 4	.0163	65	.0195	78	.0130	52	.....	.....
Tar H.T.	.4	No. 4 No. X	.0134	67	.0162	81	.0108	54	.....	.....
	.5	"	.0175	70	.0210	84	.0140	56	.....	.....
	.6	"	.0210	70	.0252	84	.0168	56	.....	.....
Tar M.T.	.3	No. 6 or S.T. Sand	.0038	25	.0045	30	.0030	20	.....	.....
	.4	No. 6	.0062	31	.0076	38	.0050	25	.....	.....
	.5	"	.0093	37	.0113	45	.0075	30	.....	.....
	.6	"	.0120	40	.0144	48	.0096	32	.....	.....
	.7	"	.0147	42	.0178	51	.0119	34	.....	.....
Tar M.T. over C.T. ½ and ½	.4	No. 6	.0052	26	.0064	32	.0042	21	.....	.....
	.5	"	.0088	35	.0105	42	.0070	28	.....	.....
	.6	"	.0117	39	.0141	47	.0093	31	.....	.....
	.7	"	.0147	42	.0175	50	.0115	33	.....	.....
Tar C. T.	.3	No. 6 or S.T. Sand	0 to .0030	0 to 20	0 to .0014	0 to 24	0 to .0024	0 to 16	0 to .0033	0 to 22
	.4	No. 6	.0040	20	.0048	24	.0032	16	.....	.....
	.5	"	.0078	31	.0093	37	.0063	25	.....	.....
	.6	"	.0108	36	.0132	44	.0087	29	.....	.....
	.7	"	.0137	39	.0161	46	.0109	31	.....	.....

KIND AND AMOUNT OF COVERING FOR BITUMINOUS TREATMENTS ON A PREVIOUSLY TREATED SURFACE OR ON A BITUMINOUS MACADAM OR BITUMINOUS CONCRETE SURFACE.

BITUMEN. Kind.	Gal. per sq. yd.	Size.*	Crushed stone. 2500 lbs. cu. yd. Tons per sq. yd.	Crushed stone. Lbs. per gal.	Gravel. 3000 lbs. cu. yd. Tons per sq. yd.	Gravel. Lbs. per gal.	Slag. 2000 lbs. cu. yd. Tons per sq. yd.	Slag. Lbs. per gal.	Sand. 2700 lbs. cu. yd. Tons per sq. yd.	Sand. Lbs. per gal.
Asphalt H. O. (s)	.3	No. 4 and No. X in each case	.0132	88	.0158	105	.0105	70	.....	.....
	.4		.0176	88	.0210	105	.0140	70	.....	.....
	.5		.0220	88	.0263	105	.0175	70	.....	.....
Asphalt H. O.	.2	No. 4 and No. X in each case	.0087	87	.0104	104	.0069	69	.....	.....
	.3		.0132	88	.0158	105	.0105	70	.....	.....
	.4		.0176	88	.0210	105	.0140	70	.....	.....
	.5		.0220	88	.0263	105	.0175	70	.....	.....
Asphalt A. C. B.	.2	No. 4	.0080	80	.0096	96	.0064	64	.....	.....
	.3	"	.0120	80	.0144	96	.0096	64	.....	.....
	.4	"	.0160	80	.0192	96	.0128	64	.....	.....
Asphalt C. O.	.2	No. 6 or S.T. Sand	.0010 to .0020	10 to 20	.0012 to .0024	12 to 24	.0008 to .0016	8 to 16	.0011 to .0022	11 to 22
	.3	"	.0020 to .0040	13 to 26	.0023 to .0046	15 to 30	.0015 to .0030	10 to 20	.0020 to .0040	13 to 26
	.4	"	.0038 to .0072	19 to 38	.0046 to .0092	23 to 46	.0030 to .0060	15 to 30	.0040 to .0080	20 to 40
Asphalt C. O. (s)	.2	No. 6 or S.T. Sand	.0013 to .0026	13 to 26	.0015 to .0030	15 to 30	.0010 to .0020	10 to 20	.....	.....
	.3	"	.0027 to .0054	18 to 36	.0032 to .0064	21 to 42	.0021 to .0042	14 to 28	.....	.....
	.4	"	.0040 to .0080	20 to 40	.0048 to .0096	24 to 48	.0032 to .0064	16 to 32	.....	.....
Asphalt C. O. (t)	.2	No. 6	.0068	68	.0081	81	.0054	54	.....	.....
	.3	"	.0102	68	.0122	81	.0081	54	.....	.....
	.4	"	.0126	68	.0162	81	.0108	54	.....	.....
Asphalt C.O. (50)	.2	No. 6	.0068	68	.0081	81	.0054	54	.....	.....
	.3	"	.0102	68	.0122	81	.0081	54	.....	.....
	.4	No. 4	.0136	68	.0162	81	.0108	54	.....	.....
Tar H.T.	.2	No. 4	.0075	75	.0090	90	.0060	60	.....	.....
	.3	"	.0113	75	.0135	90	.0090	60	.....	.....
	.4	No. 4 and No. X	.0150	75	.0180	90	.0120	60	.....	.....
Tar M.T.	.2	No. 6	.0054	54	.0065	65	.0043	43	.0059	59
	.3	No. 4	.0081	54	.00985	65	.0065	43	.....	.....
	.4	"	.0108	54	.0130	65	.0086	43	.....	.....
Tar C.T.	.2	No. 6	.0048	48	.0057	57	.0036	38	.0051	51
	.3	"	.0072	48	.0086	57	.0055	38	.0077	51
	.4	"	.0096	48	.0114	57	.0074	38	.....	.....

Notes to Tables—The bitumens referred to in the tables are:

Asphalt—H. O. (s).. Hot Oil (Special)
Asphalt—H. O. .... Hot Oil

Asphalt—M. O. .... Medium Oil
Asphalt—C. O. .... Cold Oil
Asphalt—C. O. (s)...................................... Cold Oil (Special)
Asphalt—A. C. B.. Asphalt Cut Back
Asphalt—C. O.—50....................................... Special grade of asphalt oil
Asphalt—C. O. (t)...................................... Trinidad Cold Oil
Tar—H. T. .... Hot Tar
Tar—M. T. .... Medium Tar
Tar—C. T. .... Cold Tar

*The sand sizes are as follows: No. 4 material, ¾ in. to ½ in.; No. 6, ½ in. to ¼ in.; No. X, 1¼ in. to ¾ in.; S. T. sand, surface treatment sand, ranging from ⅜ to ⅛ in size.

Where both No. X and a smaller size screening are used the coarser screenings should constitute about 75 per cent of the total covering and should be put on first. The finer screenings should be uniformly spread over the coarser as a final covering.

Treatments of the lighter tars and asphaltic oils applied during cool, damp weather may require from 10 to 25 per cent more screenings than given in the table. A greater excess under these conditions will be required on first treatments of waterbound surfaces than on retreatments.

Treatments applied during the dryest and hottest portion of the season may need from 10 to 20 per cent less screenings than given in the table for the lighter materials.

A waterbound surface that is tightly bonded will require from 5 to 15 per cent more screenings than one in which the surface stone are not well bonded and the voids are open, as would likely be the case with a hard and poor cementing stone where the surface has been insufficiently rolled and waterbound.

The tables give the quantity of covering required for average conditions. It will be necessary to use one's judgment in taking care of the special conditions which may require more or less covering than herein given.

ROAD OILING: GALLONS PER 100 FT. OF ROAD FOR DIFFERENT WIDTHS AND RATES OF APPLICATION

From Harger and Bonney's Highway Engineers' Handbook

Width in Feet	Number of Gallons to the Square Yard											
	0.1	0.2	0.25	0.3	0.33⅓	0.4	0.5	0.6	0.66⅔	0.7	0.8	0.9
8	8.89	17.78	22.22	26.67	29.63	35.56	44.44	53.33	59.26	62.22	71.11	80.00
10	11.11	22.22	27.77	33.33	37.04	44.44	55.56	66.67	74.08	77.78	88.89	100.00
12	13.33	26.67	33.33	40.00	44.45	53.33	66.67	80.00	88.89	93.33	106.67	120.00
14	15.56	31.11	38.89	46.67	51.85	62.22	77.78	93.33	103.71	108.89	124.44	140.00
15	16.67	33.33	41.67	50.00	55.56	66.67	83.33	100.00	111.11	116.67	133.33	150.00
16	17.78	35.56	44.44	53.33	59.26	71.11	88.89	106.67	118.52	124.44	142.22	160.00
18	20.00	40.00	50.00	60.00	66.67	80.00	100.00	120.00	133.33	140.00	160.00	180.00
20	22.22	44.44	55.56	66.67	74.07	88.89	111.11	133.33	148.15	155.56	177.78	200.00
22	24.44	48.89	61.11	73.33	81.48	97.78	122.22	146.67	162.97	171.11	195.56	220.00
24	26.67	53.33	66.67	80.00	88.89	106.67	133.33	160.00	177.78	186.67	213.33	240.00
26	28.89	57.78	72.22	86.67	96.29	115.56	144.44	173.33	192.60	202.22	231.11	260.00
28	31.11	62.22	77.78	93.33	103.70	124.44	155.56	186.67	207.41	217.78	248.89	280.00
30	33.33	66.67	83.33	100.00	111.11	133.33	166.67	200.00	222.22	233.33	266.67	300.00
32	35.56	71.11	88.89	106.67	118.51	142.22	177.78	213.33	237.04	248.89	284.44	320.00
34	37.78	75.56	94.44	113.33	125.92	151.11	188.89	226.67	251.86	264.44	302.22	340.00
36	40.00	80.00	100.00	120.00	133.33	160.00	200.00	240.00	266.67	280.00	320.00	360.00
38	41.11	84.44	105.56	126.67	140.73	168.89	211.11	253.33	281.49	295.56	337.78	380.00
40	43.33	88.89	111.11	133.33	148.14	177.78	222.22	266.67	296.30	311.11	355.56	400.00
42	45.56	93.33	116.67	140.00	155.55	186.67	233.33	280.00	311.11	326.67	373.33	420.00
44	48.89	97 77	122.22	146.67	162.96	195.56	244.44	293.33	325.92	342.22	391.11	440.00

Width in Feet	Number of Gallons to the Square Yard											
	1.0	1.1	1.2	1.25	1.3	1.33⅓	1.4	1.5	1.6	1.66⅔	1.7	1.8
8	88.89	97.78	106.67	111.11	115.56	118.52	124.44	133.33	142.22	148.15	151.11	160.00
10	111.11	122.22	133.33	138.89	144.44	148.15	155.56	166.67	177.78	185.19	188.89	200.00
12	133.33	146.67	160.00	166.67	173.33	177.78	186.67	200.00	213.33	222.22	226.67	240.00
14	155.56	171.11	186.67	194.44	202.22	207.41	217.78	233.33	248.89	259.26	264.44	280.00
15	166.67	183.33	200.00	208.33	216.67	222.22	233.33	250.00	266.67	277.77	283.33	300.00
16	177.78	195.56	213.33	222.22	231.11	237.04	248.89	266.67	284.44	296.30	302.22	320.00
18	200.00	220.00	240.00	250.00	260.00	266.67	280.00	300.00	320.00	333.33	340.00	360.00
20	222.22	244.44	266.67	277.78	288.89	296 30	311.11	333.33	355.56	370.37	377.78	400.00
22	244.44	268.89	293.33	305.56	317.78	325 93	342.22	366.67	391.11	407.41	415.56	440.00
24	266.67	293.33	320.00	333.33	346.67	355 56	373.33	400.00	426.67	444.44	453.33	480.00
26	288.89	317.78	346.67	361.11	375.56	385 19	404.44	433.33	462.22	481.48	491.11	520.00
28	311.11	342.22	373.33	388.81	404.44	414.82	435.56	466.67	497.78	581.51	528.89	560.00
30	333.33	366.67	400.00	416.67	433.33	444.44	466.67	500.00	533.33	555.55	566.67	600.00
32	355.56	391.11	426.67	444.44	462.22	474.08	497.78	533.33	568.89	592.58	604.44	640.00
34	377.78	415.56	453.33	472.22	491.11	503.71	528.89	566.67	604.44	629.62	642.22	680.00
36	400.00	440.00	480.00	500.00	520.00	533.33	560.00	600.00	640.00	666.67	680.00	720.00
38	422.22	464.44	506.67	527.78	548.89	562.97	591.11	633.33	675.56	703.70	717.78	760.00
40	444.44	488.89	533.33	555.56	577.78	592.60	622.22	666.67	711.11	740.73	755.56	800.00
42	466.67	513.33	560.00	583.33	606.67	622.22	653.33	700.00	746.67	777.78	793.33	840.00
44	488.89	537.78	586.67	611.11	635.56	651.85	684.44	733.33	782.22	814.81	831.11	880.00

QUANTITY TABLE FOR APPLICATION OF CALCIUM CHLORIDE AS A DUST LAYER

Width of Road Treated.—Ft.	Rate ½-lb. per sq. yd.		Rate ¾-lb. per sq. yd.		Rate 1 lb. per sq. yd.		Rate 1¼ lb. per sq. yd.		Rate 1½ lb. per sq. yd.	
	Lbs. per 100 lin. ft. road.	Tons per mi. of road.	Lbs. per 100 lin. ft. road.	Tons per mi. of road.	Lbs. per 100 lin. ft. road.	Tons per mi. of road.	Lbs. per 100 lin. ft. road.	Tons per mi. of road.	Lbs. per 100 lin. ft. road.	Tons per mi. of road.
8	45	1.17	67	1.76	89	2.34	111	2.93	134	3.52
12	66	1.76	100	2.64	133	3.52	167	4.40	200	5.28
16	89	2.35	133	3.52	178	4.70	222	5.86	267	7.04
20	111	2.93	167	4.40	222	5.86	278	7.34	333	8.80
24	132	3.52	200	5.28	267	7.04	334	8.80	400	10.56

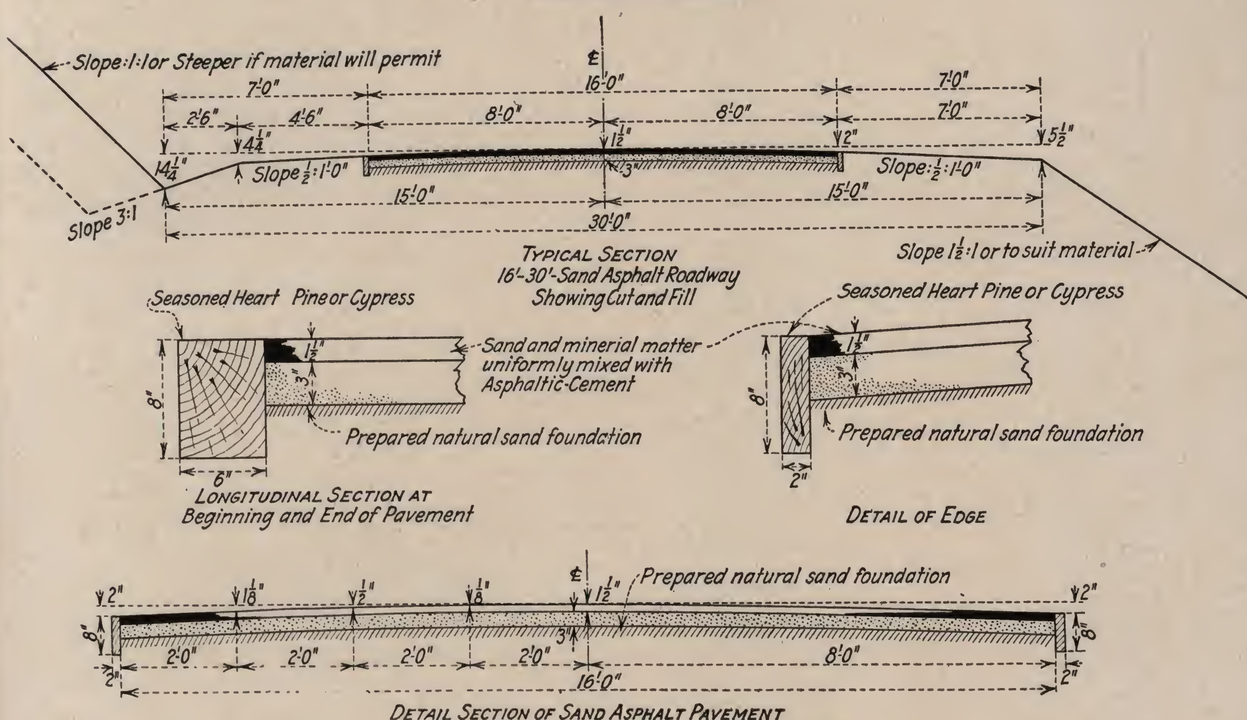
WEIGHTS AND MORTAR PER JOINT FOR VITRIFIED PIPE

From Standards for Field and Office Practice Kentucky State Department of Roads

Inside diam. in	Single strength pipe				Double strength pipe				Mortar per jnt cu. ft.	Lin. ft. per c. y. of sand	Lin. ft. per sk. cement
	t in.	b in	c in.	Wt. per foot in.	t lb.	b in.	c in.	Wt. per foot in.			
15	1⅛	2½	½	60	1¼	2½	½	75	.092	942	35
18	1¼	2¾	½	85	1½	2¾	½	118	.118	717	27
20	1⅜	3	½	100	1⅔	3	½	138	.142	605	22
24	1⅝	3¼	½	150	2	3¼	½	190	.189	449	17
30	2⅛	4	¾	252	2½	4	¾	290	.373	350	13
36	2½	5	1¼	350	2¾	5	1¼	375	.764	168	6

Quantities figured for 2 ft. lengths to 24 in. diameter and 3 ft. lengths above 24 in. Note—t=thickness of shell; b=depth of socket; c=thickness mortar joint. Mortar is 1:1 mix.

Sand Asphalt Pavement



Standard Sections for Sand Asphalt Pavement.
North Carolina State Highway Department.

SAND ASPHALT BASE AND SURFACE COURSES

Specifications of State Highway Commission of North Carolina

1. General Description. (a) The base course shall consist of coarse sand, uniformly mixed with asphaltic cement, and shall be laid to a finished thickness of three (3) inches upon a prepared sand foundation, as herein specified.

(b) The surface course shall consist of sand and mineral filler, uniformly mixed with asphaltic cement, and shall be laid upon the compacted base course to a finished thickness of two (2) inches.

(c) A squeegee coat of hot asphaltic cement shall be spread on the base course prior to laying the wearing surface, in quantity not to exceed one-sixteenth (1/16) gallon per square yard, by an approved asphalt spreader, not later than twenty-four (24) hours after the laying of the base course, unless approved by the Engineer. The asphaltic cement for this squeegee course shall be heated in approved kettle or tanks brought to a temperature of 225° F. to 350° F. on the road as directed by the Engineer.

(d) All materials and methods of preparation and construction shall conform to the requirements of these specifications.

2. Sand for Base Course. The sand for base course shall consist of clean, hard, durable grains, free from clay, loam or other foreign matter, and when tested shall all pass a one-quarter (¼) inch laboratory screen, and be graded from coarse to fine.

3. Sand for Surface Course. The sand for surface course shall consist of clean, hard, durable grains, free from clay, loam and other foreign matter, and when tested by means of laboratory sieves shall meet the following requirements (unless otherwise permitted in writing by the Engineer):

Passing	Retained on	Per Cent	
10 mesh		98 to 100	
10 mesh	20 mesh	3 to 15	14 to 50
20 mesh	30 mesh	4 to 15	
30 mesh	40 mesh	5 to 25	
40 mesh	50 mesh	5 to 30	30 to 60
50 mesh	80 mesh	5 to 40	
80 mesh	100 mesh	6 to 20	16 to 40
100 mesh	200 mesh	10 to 25	
200 mesh		0 to 5	

4. Mineral Filler. The mineral filler shall consist of thoroughly dry limestone dust, slate dust, Portland cement, or other material approved in writing by the Engineer, which, when tested by means of laboratory sieves, shall meet the following requirements:

Passing 30 mesh sieve....................100 per cent
Passing 200 mesh sieve, not less than.................... 65 per cent

5. Asphaltic Cement. The asphaltic cement shall be homogenous, free from water, and shall not foam when heated to 175° C. (347° F.). It shall meet the following requirements for physical and chemical properties:

I. Specific Gravity, 25°/25° C. (77°/77° F.), not less than..1.000
II. Flash Point, not less than....................175° C. (347° F.)
III. Penetration at 25° C. (77° F.), 100 g., 5 sec.. 40-50
IV. Ductility at 25° C. (77° F.), not less than....................30
V. Loss at 163° C. (325° F.), 5 hours, not more than....3 per cent
Penetration of residue at 25° C. (77° F.), 100 g., 5 sec., as per cent of original penetration, not less than ....50 per cent
VI. Per cent of total bitumen soluble in carbon tetrachloride, not less than....................99 per cent

6. Sources of Supply. (a) Approval of all materials entering into sand asphalt roadway under these specifications shall be obtained from the Engineer prior to delivery of material, and samples of each shall be submitted as directed by the Engineer.

(b) A one (1) pound sample of the asphaltic cement that the Contractor proposes to use in his work, together with a statement as to its source and character, must be submitted before work commences. If the Contractor proposes to prepare the asphaltic cement at the paving plant, then in lieu of the above a one (1) pound sample each of flux and refined asphalt must be submitted, together with a statement as to the source and character of each and proportions in which they will be combined to produce the asphaltic cement which he proposes to use. No asphaltic cement, flux or refined asphalt other than that approved shall be used by any Contractor, except with the written consent of the Engineer, and provided that the asphaltic cement used shall comply in all respects with the requirements of these specifications.

PREPARATION AND COMPOSITION OF MIXTURES

7. Preparation of Asphalt Cement. (a) The asphaltic cement shall be melted at the paving plant in kettles or tanks designed to secure uniform heating of the entire contents, and shall be brought to a temperature of 250° F. to 350° F.

(b) When a refined asphalt is to be combined with a flux, the mixture shall be thoroughly agitated until a homogenous asphaltic cement of the required penetration is produced. The penetration of the asphaltic cement shall be tested at suitable intervals to insure that it is maintained at a uniform consistency throughout the period of use.

8. Preparation of Mineral Aggregates. (a) The sand for base course shall be dried and heated at the paving plant in suitably designed revolving driers. It shall be heated to a temperature of 225° F. to 350° F., as determined on the mixing platform.

(b) The sand for surface course aggregate shall be separately dried, heated and stored at the paving plant, as described in the preceding paragraph. The sand shall be heated to a temperature of 275° F. to 400° F., as determined on the mixing platform. When a mixture of two or more sands is required in order to produce a material conforming to the requirements of Par. 3, such combination shall be made either before the sand is fed into the drier, or by simultaneously feeding the individual sands into the drier in proper proportions.

9. A registering pyrometer shall be installed at a suitable point at the discharge end of the drier, with the registering device so located as to clearly indicate to the drum fireman the temperature of the mineral aggregate when discharged.

10. Preparation and Composition of Base Course Mixture. (a) The hot aggregate for base course shall be measured accurately by weight for each batch to be mixed. The required quantity of hot asphaltic cement for each batch shall be measured by actual weighing with scales attached to the asphaltic cement bucket. The mixture shall be made in an approved twin pug mill mixer by first charging it with the mineral aggregate, and then adding the asphaltic cement. Mixing shall then be continued for a period of at least forty-five (45) seconds, or longer if necessary to produce a homogenous mixture in which all particles of the mineral aggregate are uniformly coated.

The ingredients shall be heated and combined in such a manner as to produce a mixture which, when discharged, shall not vary more than thirty (30) degrees F. from temperature set by the Engineer and within the limits herein specified. Any mixture varying more than thirty (30) degrees F. from the limits set shall be rejected. Every effort should be made to have the mixture leave the plant as near a constant temperature as possible.

(b) The constituents of the base course shall be sand and bitumen combined in such proportions as to produce a mixture conforming to the following composition limits, by weight:

Mineral Aggregate	Per Cent of Total Mixture
Sand	91-94
Bitumen	6-9

The proportions shall be varied between the limits designated, as directed by the Engineer.

11. Preparation and Composition of Surface Course Mixture. (a) The hot sand and the mineral filler shall be measured separately and accurately, by weight, for each batch to be mixed. The hot asphaltic cement for each batch shall be measured by actual weighing with scales attached to the asphaltic cement bucket. The mixture shall be made in an approved twin pug mill mixer by first charging it with sand and mineral filler. After the two have been thoroughly mixed, the asphaltic cement shall be added and the mixing continued for a period of at least one (1) minute, or longer if necessary, to produce a homogenous mixture in which all particles of the mineral aggregate are uniformly coated. The ingredients shall be heated and combined in such a manner as to produce a mixture which when discharged shall not vary more than 30° F. from temperature set by the Engineer within the limits herein specified.

(b) The constituents for the surface course shall be combined in such proportions as to produce a mixture conforming to the following composition limits, by weight:

	Per Cent
Passing 10 mesh, retained on 40 mesh sieve	10 to 40
Passing 40 mesh, retained on 80 mesh sieve	22 to 45
Passing 80 mesh, retained on 200 mesh sieve	12 to 30
Passing 200 mesh sieve	10 to 15
Bitumen soluble in carbon tetrachloride	9.5 to 12

The proportions shall be varied within the limits designated, as directed by the Engineer.

The percentage of bitumen in the finished wearing surface shall not show a greater variation than one-half of one per cent, plus or minus, from the amount in the formula approved by the State Highway Engineer.

12. Paving Plant Inspection. For the verifications of weights or proportions and character of materials and determination of temperatures used in the preparation of the mixtures, the Engineer or his authorized representatives shall have access at any time to all parts of the paving plant.

13. Transportation of Mixtures. The base course and surface course mixtures shall be transported from the paving plant to the work in tight vehicles previously cleaned of all foreign materials, and when directed by the Engineer, each load shall be covered with canvas or other suitable materials of sufficient size and thickness to protect it from weather conditions. No loads shall be sent out so late in the day as to interfere with spreading and compacting the mixtures during daylight, unless artificial light satisfactory to the Engineer is provided.

CONSTRUCTION

14. Sand Foundation. (a) All ditches shall be completed before paving operations are started, or as directed by the Engineer.

(b) The roadway and approaches shall be graded to such lines and cross-sections that when rolled, the finished surface of the sand foundation shall conform to that shown on the plans and cross-sections. Where the prepared sand foundation has become rutted or deformed, it shall be scarified, if necessary, re-shaped and re-rolled to its former section and grade.

(c) All vegetable matter, muck or quicksand, which will not compact by rolling shall be removed and replaced with material which can be compacted.

(d) Where there is a deficiency of sand in the sub-grade, or the sub-grade is otherwise unsatisfactory, original sub-grade shall be removed and replaced with sand or other satisfactory materials as directed by the Engineer. This material shall be placed and properly compacted as directed.

(e) The sand shall be thoroughly wet down and then well rolled. The roller used in compacting sand shall be of the self-propelling type, or a horse-drawn ring embankment roller, weighing at least two (2) tons.

Rolling shall continue until the sand is thoroughly compacted. Any depression in the surface thereof developed by the rolling shall be filled and then rerolled. After the sand has been thoroughly rolled it shall be carefully shaped to a true cross-section, parallel with the finished roadway. The operation for accurately shaping the sand foundation for the base course is of prime importance to secure the desired evenness of the surface of the finished pavement, and the Contractor shall be required to equip himself with proper implements and to secure skilled men for this part of the work.

15. Forms. Timber forms shall be used to hold the roadway material in place. They shall be of long-leaf pine or square-edged pine from original growth, cypress, or other lumber which is square-edged and cut true to dimensions. Timber shall be sound, straight and free from warps. It shall be two (2) inches in thickness and eight (8) inches in depth. The length shall be from ten (10) to fifteen (15) feet.

The forms shall be firmly set and staked to correct line and grade and left in place after the pavement is completed. Stakes shall be placed at two (2) foot intervals, or closer, if necessary, and the forms spiked securely thereto. The depth of the trench excavated to receive the form shall not exceed one-half (½) inch below the grade line established by the bottom of the form. All backfill in form trench shall be firmly compacted by tamping.

No less than five hundred (500) feet of forms shall be in place at any one time. All forms in place shall be true to line and grade at the time of laying pavement, and shall be backfilled with suitable material for a distance of at least two (2) feet outside.

Care shall be exercised in rolling, so as not to displace the line and grade of forms.

16. Placing Base Course Mixture. No base course shall be laid when the temperature is less than 30° F. in the shade away from artificial heat, unless permitted in writing by the Engineer. Where night work is permitted no material shall be laid when the air temperature away from artificial heat is less than 35° F. Prior to the arrival of the base course mixture on the work, the prepared sand foundation shall be cleaned of all loose and foreign materials. The mixture shall be delivered at the temperature specified by the Engineer, and shall be between 265° F. and 325° F. It shall be laid only upon a base which is dry or, at least, free from standing water, and only when weather conditions are suitable. The Engineer may permit, however, work of this character to continue, when overtaken by sudden rain, up to the amount which may be in transit from the plant at the time, provided the mixture is within temperature limits specified. Upon arrval on the work, the base course mixture shall be dumped on approved steel dump boards outside of the area on which it is to be spread, and shall then be immediately distributed into place by means of hot shovels and spread with hot rakes in a uniformly loose layer of correct depth. The amount of base course placed in advance of laying the surface course shall be determined by the Engineer.

17. Compacting Base Course. (a) As soon after spreading as possible, the base course shall be rolled with a six (6) to eight (8) ton tandem roller. All rollers used shall be kept in good condition and shall weigh not less than two hundred (200) pounds to the inch width of tread. Each roller shall be in charge of a competent, experienced roller engineer and must be kept in continuous operation as near as practicable. Rolling shall start longitudinally at the sides and gradually proceed toward the center of the pavement. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture, and any displacements shall at once be corrected by the use of rakes and of fresh mixture where required. Rolling shall proceed at an average rate not to exceed two hundred (200) square yards per hour per roller, and shall continue until no further compression is possible. To prevent adhesion of the base course mixture to the roller, the wheels shall be kept properly moistened, but an excess of either water or oil will not be permitted.

(b) At all places not accessible to the roller the base course shall be thoroughly compacted with hot tampers.

(c) The surface of the base course after compression shall be two (2) inches below and parallel to the established grade of the finished pavement. The surface of the base course shall be checked for smoothness after initial compression, with a ten (10) foot straight edge, and any irregularities in excess of five-eights (⅝) inch in ten (10) feet shall be corrected immediately by the addition of fresh mixture. The surface after compression shall show at no place an excess of asphaltic cement, and any spot showing such excess shall be cut out and replaced with fresh hot base mixture and immediately compacted to conform with the surrounding area. Any base mixture which becomes loose or broken, mixed or coated with dirt, or in any way defective, prior to laying the surface course, shall be removed and replaced with fresh, hot base course mixture, which shall be immediately compacted to conform with the surrounding area.

18. Joints in Base Course. Placing of the base course mixture shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the base course is to be discontinued for such length of time as to permit it to become chilled. In such case the base course

shall be trimmed back to the full specified thickness before laying fresh hot mixture against it. In any case, when the laying of the base mixture is continued, it shall be placed in close contact to the exposed edge of the base course previously laid, so that an even well-compacted joint is produced after rolling.

19. Placing Surface Course Mixture. (a) No surface course shall be laid when the temperature is less than 30° F. in the shade away from artificial heat unless permitted in writing by the Engineer. Prior to delivery of the surface course mixture the base course shall be kept clean and free from traffic with the possible exception of mixture vehicles and the sand foundation shall be planked where required by the Engineer, for a distance of at least fifty (50) feet from the end of the base before hauling over it. If not thoroughly clean, it shall be swept off immediately before the surface course mixture is placed. The mixture shall be delivered at the temperature specified by the Engineer and shall be between 265° F. and 350° F. It shall be placed only when weather conditions are suitable. Upon arrival on the work, the surface course mixture shall be dumped on approved steel dump boards, and shall then be immediately distributed into place by means of hot shovels and spread with hot rakes in a uniformly loose layer of correct depth.

The depth of this layer shall be gaged at least every three feet by means of a template cut to proper crown and section of roadway as shown on sheet of standards, allowing sufficient depth for compression. Any deviation from standard crown and section as indicated by template shall be immediately remedied by placing new or removing surplus material.

Straight edging and back-patching shall be done after initial compression has been secured and while material is still hot.

(b) Contact surfaces of curbings, forms, gutters, manholes, etc., shall be painted with a thin, uniform coating of hot asphaltic cement, or asphaltic cement thinned with naphtha, just before the surface mixture is placed against them. Immediately adjacent to headers, flush curbings, gutters, liners, and other structures, the surface course mixture shall be spread uniformly high, so that after compaction it will be slightly above the edges of such structures.

20. Compacting Surface Course. (a) The compression of the top course, or wearing surface, shall be secured with a six (6) to ten (10) ton tandem roller. All rollers used shall be kept in good condition, and shall weigh not less than two hundred (200) pounds to the inch width of tread. Each roller shall be in charge of a competent, experienced roller operator, and must be kept in continuous operation as nearly as practicable. The ashes from the roller must not be dumped upon the base or wearing surface courses. Rolling shall start longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least one-half (½) the width of the roller. The pavement shall then be subjected to diagonal rolling in two directions, the second diagonal rolling crossing the lines of the first. If the width of the pavement permits, it shall in addition be rolled at right angles to the center line. Rolling shall be continued until all roller marks are eliminated. The motion of the roller shall at all times be slow enough to avoid displacement of the hot mixture, and any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall at once be corrected by the use of rakes and of fresh mixture where required. Rolling shall proceed at an average rate not to exceed one hundred and fifty (150) square yards per hour per roller, and shall continue until no further compression is possible. To prevent adhesion of the surface mixture to the roller, the wheels shall be kept properly moistened, but excess of either water or oil will not be permitted. Before final compression a light, uniform coating of limestone dust or Portland cement shall be swept over the surface of the pavement and the rolling then continued.

(b) Along curbs, headers and similar structures, and all places not accessible to the roller, the surface mixture shall be thoroughly compacted with hot tampers to produce sealed joints.

(c) The surface of the pavement after compression shall be smooth and true to the established crown and grade. Any defective places shall be immediately remedied by removing the surface course mixture at such spots and replacing it with fresh, hot surface course mixture, which shall be immediately compacted to conform with the surrounding area.

The finished pavement surface shall show no deviation from the general surface in excess of one-sixteenth (1-16) inch per foot, as measured in the following manner: a ten (10) foot straightedge shall be placed parallel to the center line of the roadway, so as to bridge any depressions. Ordinates measured from the face of the straightedge to the surface of the pavement shall not exceed one-sixteenth (1-16) inch for each foot in distance from the nearest point of contact.

21. Joints in Surface Course. Placing of the surface course shall be as nearly continuous as possible, and the roller shall pass over the unprotected end of the freshly laid mixture only when the laying of this course is to be discontinued for such length of time as to permit the mixture to become chilled. In all such cases, including the formation of joints as hereinafter specified, provision shall be made for proper bond with new surface mixture by cutting or trimming back the joint while the material is still hot, so as to expose an unsealed or granular surface for the full specified depth of the course.

At the end of each day's work on surface mixture, joints shall be formed by laying and rolling against boards of the thickness of the compacted mixture placed across the entire width of the pavement, or by such other method as may be approved by the Engineer. When the laying of the surface mixture is resumed, the exposed edge of the joint shall be painted with a thin coat of hot asphaltic cement, or asphaltic cement thinned with naphtha, and the fresh mixture shall be raked against the joint, thoroughly tamped with hot tampers, and rolled. Hot smoothing irons may be used for sealing joints, but in such case extreme care shall be exercised to avoid burning the surface.

Such portions of the completed pavement as are defective in finish, compression, density or composition, or that do not comply in all respects with the requirements of these specifications, shall be taken up, removed and replaced with suitable material properly laid in accordance with these specifications.

22. Protection of Pavement. If the time of laying base and surface course mixtures permanent side supports, such as curbs, timber forms, headers, edgings or gutters, have not been constructed, planks of suitable thickness shall be laid along each side of the pavement and rigidly supported, so as to prevent the mixture from squeezing out under the roller. These planks shall remain in place until final compaction has been obtained. Sections of newly compacted base and wearing course shall be protected from traffic for at least six (6) hours, until they have become properly hardened by cooling. After the construction of the shoulders, the surface of the pavement shall be cleaned of all foreign material.

23. Plant and Equipment. For the determination of the temperatures and quantities of materials used throughout the process of manufacture, the Contractor shall provide and maintain at the plant suitable thermometers, not less than two platform scales, and such other weighing apparatus as is required by the specifications.

The plant used in preparing all bituminous paving mixtures must be of the batch type, capable of mixing in the manner herein specified, and must be provided with separate chambers for heating and mixing the ingredients.

No direct heat except steam shall be applied to the exterior surface of the mixing chamber. No flames shall be allowed to pass through the mixing chamber. The heat must be so regulated that the sand can easily be heated to and maintained at the required temperature.

24. Field Laboratory. The Contractor shall also provide a field laboratory in which to house and use the testing equipment, said laboratory to be not less than ten (10) feet wide, twelve (12) feet long and seven (7) feet high, floored, contain not less than two windows and work bench with the necessary drawers; this laboratory to be used exclusively for testing purposes by the Engineer or Inspector, and shall be so located that the mixing platform shall be in full view from the laboratory.

25. Basis of Payment. This work will be paid for at the contract unit price per square yard for "Sand Asphalt Base and Surface Courses," complete in place, which price shall include all forms, preparation of sand foundation, materials, equipment, tools, labor and work incidental to complying with the specifications. Except that when sand necessary for the proper preparation of subgrade is hauled in, it will be paid for as borrow or excavation as the case may be, unless otherwise stated in Special Provisions.

COST OF SAND ASPHALT ROAD

The methods employed in constructing some 40 miles of sand-asphalt pavement in North Carolina by state forces were described in Roads and Streets by E. R. Oldbrich, formerly construction engineer of the North Carolina State Highway Commission. In this article Mr. Oldbrich gives the following cost summary for two weeks' work on one of these jobs. The pavement consisted of a 3-in. base course composed of 8 per cent asphalt and 92 per cent sand, and a top course of 1½ in. thick composed of 10.5 per cent asphalt, 12 per cent dust and 77.5 per cent sand. The edgers were 2x8-in. cypress or long leaf pine.

NORTH CAROLINA STATE HIGHWAY COMMISSION

Fortnightly Cost Summary Sand Asphalt Operation

District 2. County Carteret. Project No. 200-B

	Cost per sq. yd.	
Hauling sand to drier	.078	$ 36,190
Labor drying sand	.027	12,425
Fuel oil used drying sand	.131	64,100
Labor mixing	.017	8,200
Asphalt in mix	.300	139,267
Dust in mix	.062	28,918
Fuel for boiler—coal, wood, lubricating oil	.040	18,164
Plant repairs, including plant engineer	.032	14,748
Railroad demurrage on asphalt tank cars	.027	12,700
Rent on asphalt tank cars	.010	4,600
Other plant labor	.076	35,505
Total plant operation	.81	$374,817
Truck drivers' pay roll	.034	$ 15,450
Gasoline and oil for trucks	.046	22,213
Repairs, including mechanic	.011	4,975
Gas, oil and repairs road equipment	.019	9,128
Total hauling to road	.11	$ 51,766

Headers, labor	.028	$ 13,000
Material in headers	.066	30,862
Fine grading labor	.036	16,660
Laying, raking and rolling hot mix	.108	50,335
Shoulders	.031	15,100
Total road operation	.27	$125,957
Suprintendence and timekeeping	.037	$ 17,950
Depreciation, plant equipment	.029	13,722
Depreciation, road equipment	.012	6,161
Interest	.013	6,553
Total incidentals	.09	$ 44,386
Total gross cost		$596,926
Total gross cost, forwarded		$596,926
Deductions (itemize):		
Shoulders		15,100
Total deductions		$ 15,100
Total net cost		$581,826

Performance

Headers (lin. ft. of road)	2,200
Fine grading (cubic yards) 2,000 lin. ft.	240
Shoulders 7 ft. width (lin. ft. of road)	2,700
Base (square yards)	4,889
Wearing surface (square yards)	3,731
Number working days	13
Number days worked, 108 hours	12

Total net cost, $5,818.26.
Cost per square yard, $1.25.
Sq. yds. surface, 4,655.0.
Total No. sq. yds. laid to date, 37,884.0.
Percentage of total, 26.6.
Average cost per sq. yd. to date, $1.38.

The cost of the first 10 miles of sand-asphalt finished was $1.37 per square yard without the shoulder work. This figure includes allowance for interest, depreciation and overhead. The shoulder cost was about 10c per square yard, or about $700 per mile. The average cost varies from $1.30 to $1.80 per square yard.

The total cost of plant, camp, hauling and road equipment, and accessories necessary to properly outfit a job of this kind, is from $22,000 to $25,000. Of this about $12,000 is cost of plant equipment and accessories. If a larger type of plant is used, and larger trucks, the total cost may greatly exceed this figure.

Mr. H. C. Weathers, Construction Engineer of the North Carolina State Highway Commission, advises us that about 20 cts. should be added to the final cost per square yard for engineering, inspection, etc. He also states that recent improvements in the pavement and its construction have increased the cost a little. The bid price for this type of pavement during 1924 was from $1.45 to $2 per square yard.

Mr. Weathers has also furnished the following summary showing the cost of sand asphalt operation on a job in Onslow County, North Carolina:

Fortnightly Cost Summary
Plant No. 2, Project No. 366, District 3

	Cost per sq. yd.	
Hauling sand to drier	$0.099	$ 430.50
Labor drying sand	0.037	163.50
Fuel oil used drying sand	0.061	266.00
Labor mixing	0.063	272.70
Asphalt in mix	0.308	1,343.07
Dust in mix	0.070	306.40
Fuel for boiler—coal, wood, lubricating oil	0.036	155.37
Plant repairs, including plant engineer	0.039	168.19
Railroad demurrage on asphalt tank cars	0.010	43.00
Rent on asphalt tank cars	0.003	14.00
Total Plant Operation	$0.726	$3,162.73
Truck drivers' pay roll	0.064	$ 277.20
Gasoline and oil for trucks	0.080	348.79
Repairs, including mechanic	0.021	93.56
Total Hauling to Road	$0.165	$ 719.55
Headers, labor	0.073	320.09
Material in headers	0.104	454.15
Fine grading, labor	0.024	104.70
Laying, raking, and rolling hot mix	0.141	612.36
Shoulders		401.16
Filling washouts		19.90
Total Road Operation	$0.342	$1,912.36
Extra work (describe)—		
Tools purchased		$ 128.95
Roller repairs	0.013	55.72
Camp supplies	0.001	4.00
Camp erection		20.25
Equipment		150.00
Total Extra Work	$0.014	$ 358.92
Superintendence and timekeeping	$0.048	$ 209.43
Depreciation, road equipment	0.170	740.86
Interest	0.012	51.42
Miscellaneous, cook	0.007	32.50
Total Incidentals	$0.237	$1,034.21
Total Gross Cost		$7,187.77
Deductions—		
Shoulders		$ 401.16
Filling washouts		$ 19.90
Tools purchased		128.95
Camp erection		20.25
Equipment		150.00
Total Deductions		$ 720.26
Total Net Cost		$6,467.51

Performance

Headers (lin. ft. of road)	3,500
Fine grading (cubic yards)	200
Shoulders 6 ft. width (lin. ft. of road)	3,500
Base (square yards)	4,597
Wearing surface (square yards)	4,120
Total net cost, per sq. yd.	$1.48
Average cost to date, per sq. yd.	$1.69

Construction Organization and Equipment.—We are indebted to Mr. Weathers for the following information regarding the organization, equipment and wages of a typical gang for the construction of sand asphalt pavement:

Plant Organization

1 Superintendent	at $6.50
1 Foreman	at 6.00
1 Mixer Man	at 4.50
1 Plant Fireman	at 3.50
1 Drum Fireman	at 3.50
1 Night Fireman	at 4.50
1 Plant Engineer	at 5.00
1 Dust Man	at 2.50
1 Oiler	at 2.50
3 Sand Feeders	at 2.50
2 Teams	at 6.00
1 Yard Porter	at 2.50

Plant Equipment

1 Asphalt Plant.	1 Tool House.
1 Asphalt Storage Tank.	1 Inspector's House.
1 Fuel Oil Storage Tank.	1 Spare Parts Shed.
1 Dust House.	Camp, if necessary.

Equipment bringing sand from pit to plant—five teams $30.00 per day or one tractor and three self-loading wheelers $30.00 per day.

Hauling Equipment

(Assuming output to be 200 tons, one mile haul)

5 Trucks at $12.50 per day.
1 Mechanic at $5.00 per day.
General garage tools.

Road Organization

1 Foreman	at $6.00
2 Teams	at 6.00
1 Fine grader and header foremen	at 5.00
5 Header men—2 at $3.00 and 3	at 2.50
5 Fine Grade men, 1 at $3.50 and 4	at 2.50
2 Tampers	at 3.00
6 Shovelers	at 2.75
3 Rakers	at 5.00
2 Rollermen	at 5.00
1 Waterboy	at 1.50
1 Fordson man	at 3.50

Road Equipment

1 8-ton tandem roller.
1 4-ton 3-wheeler roller.
1 Dump Board.

Shovels, rakes, tamps, 1 firewagon, 1 water cart, 1 turntable, sledges, saws, 1 grade template, 1 sub-grade template, drag pans and Fresno scraper, 1 road machine.

1 Fordson.
2 in. x 8 in. wooden forms, stakes and nails—$800 per mile.

THE BARRETT COMPANY

40 Rector Street, New York, N. Y.

Manufacturers of Tarvia

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Tarvia
For Road Construction Repair and Maintenance

"Tarvia-A" for Hot Surface Applications.

"Tarvia-A" is a refined coal tar which has been especially developed for hot surface treatment work. It has the peculiar characteristic of penetrating and filling voids, and also forms a protective coating on the surface.

"Tarvia-A" forms a tough, hard, impervious mat which will not push or wave. Its granular, non-skid surface is especially desirable on roads over which a large number of rubber tired vehicles must be carried.

One of the outstanding uses for "Tarvia-A" is in the protection of cement concrete roads. It is also extensively used for the surface treatment of water bound macadam, bituminous macadam, bituminous concrete, brick and block roads and pavements.

"Tarvia-B" for Cold Surface Applications.

"Tarvia-B" is a refined tar which can be applied cold. It will penetrate into the surface of gravel or macadam roads and bind the particles together.

"Tarvia-B" is the outstanding material for the surface treatment of gravel roads. It will change a dusty gravel surface into a smooth, hard, impervious, non-skid, absolutely dustless surface which will not rut or wave.

"Tarvia-B" is used both as a prime coat and as a final surface on macadam roads. Where there is a large amount of horse drawn, steel tired traffic "Tarvia-B" should be used for the surface coat.

"Tarvia-B" is the binder for Tarvia "Re-Tread," which is a thin stone top coating for macadam, shale and gravel roads.

"Tarvia-B" revives and waterproofs the surface of bituminous macadam and bituminous concrete roads.

"Tarvia-B" is easy to handle because it can be applied cold. It does not require extensive equipment and only ordinary care is needed to obtain excellent results.

"Tarvia-A" Over Concrete, Du Pont Avenue, Minneapolis, Minn.

"Tarvia-B" Over Waterbound Macadam, Grand Concourse, New York City

Continued on Next Page

"Tarvia-X" for Hot Binder.

"Tarvia-X" is a strong, durable, waterproof binder used in the construction of roads and pavements. "Tarvia-X" is used in the penetration method under a wide variety of specifications that are suitable for city and suburban streets and state and country roads.

"Tarvia-X" is shipped in tank cars equipped with steam coils and ordinary steam pressure is sufficient to heat it to its application temperature. "Tarvia-X" is easily handled on the road and readily penetrates down into the stone and binds it together.

"Tarvia-X" is a standard material for hot patching and repairing all types of pavements. Bituminous macadam and bituminous concrete, in preparation for surface treatment, lend themselves well to Tarvia patching.

Barrett Pressure Distributor Applying "Tarvia-X"

"Tarvia-X" is adapted to bituminous mixed work such as close mix, Topeka Mix, Tarvia Concrete, etc.

Roads built with "Tarvia-X" as a binder are durable, dustless, non-skid and will not rut or wave.

"Tarvia-XC," a special grade, is supplied for filling the joints and the cracks in cement concrete pavements. It is also used for repairing holes, and building up corners of concrete that have failed. After all holes and depressions have been patched, "Tarvia-A" is recommended for a surface treatment. Very wide cracks may be filled with a mastic made of "Tarvia-XC" and sand.

Cracks and holes in brick pavements may be repaired with "Tarvia-XC."

The Barrett Company maintains a fleet of modern pressure distributors for the application of Tarvia. These are available at many of the Company's plants and service stations.

"Tarvia-KP" for Cold Patching.

"Tarvia-KP" is the maintenance man's friend and has been developed for the patching and preservation of pavements.

Mixed with the proper aggregate, "Tarvia-KP" forms a tar concrete which makes a strong, durable patch. It is easily mixed by hand or in an ordinary concrete mixer.

"Tarvia-KP" mix can be stored and used when needed. It will keep indefinitely. Freezing will not injure either "Tarvia-KP" or a "Tarvia-KP" mix.

Less "Tarvia-KP" per cubic yard is required to make a strong patch than any other patching material because of the high binder content in "Tarvia-KP."

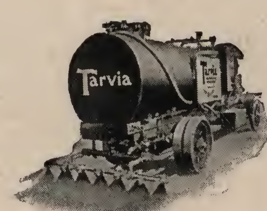
"Tarvia-KP" requires no heating and is used cold both for making patching material and for surface treatments.

"Tarvia KP" Pavement, Loch Raven, Maryland

"Tarvia-KP" is used as a binder in pavements of the cold mixed type.

"Tarvia-KP" has a multiplicity of uses. It is used for building up a mat coat over plank floors on bridges, for widening old pavements, for paint coating cement gutters, for emergency patches of wood block and other pavements, for resurfacing old pavements, for waterproofing concrete and for grade crossings.

"Tarvia-KP" costs less because it goes further.



ASPHALT BRICK CO.

5201-19 South 38th St., St. Louis, Mo.

Manufacturers of ABC Asphalt Brick

Products: ABC ASPHALT BRICK.

ABC Asphalt Brick is being used by Highway and Street Commissioners in paving streets, bridge floors, railroad crossings; plumbers' cuts are repaired with the aid of Stelzer trench covers.

ABC Asphalt Brick is manufactured from a bituminous rock asphalt having the proper kind of aggregate and containing the correct percentage of bitumen. This material is crushed, treated, heated and then pressed in the largest brick presses made in the United States. The ram of these presses delivers over 300,000 pounds of pressure. This process turns out a brick that is unlike all others, with qualities that make it superior to any known material for paving or flooring purposes.

Paving Streets: Because of its tough resistance to heavy traffic ABC Asphalt Brick is the perfect material for heavy duty thoroughfares. No hot plant or roller is necessary in the installation of the brick. A level must be struck off and the brick placed tightly into position—the traffic welds it into a waterproof, resilient and NON-SKID street, without the use of filler.

Bridge Floors: Because of its many distinctive properties ABC Asphalt Brick is an ideal material for bridge floors. Traffic can be resumed as soon as the brick is laid.

A Neat Repair

Railroad Crossings: ABC Asphalt Brick is used extensively in grade crossings because of its economy, long wearing qualities and the fact that it does not rut or loosen with the vibration of moving trains.

The Stelzer Trench Cover

Plumber and Utility Cuts: After a thorough trial extending over a long period of time under severe traffic conditions, it has been demonstrated that the ABC Method of repairing plumber and utility cuts is the only way to make a permanently smooth wearing surface in pavements without waiting for the fill to settle. This method is used in St. Louis, and is being endorsed by progressive authorities everywhere.

Write us for detailed information on how you can use ABC Asphalt Brick.

Superior Features:

1. Will not rut or push ahead of truck wheels.
2. Does not get soft or wavy with extreme temperature changes.
3. Provides a non-skid surface even in wet weather.
4. No special tools, rollers or hot plant required to lay.
5. Traffic makes joints adhere, providing a waterproof surface.
6. Impervious to mild acids and alkalies.

F. J. LEWIS MFG. CO.

2500-2600 South Robey Street, Chicago, Illinois

Coal Tar Products

PLANTS

Chicago, Ill.
Chattanooga, Tenn.

St. Louis, Mo.
Fairmont, W. Va.

Dover, Ohio
Newark, N. J.

Lewis ROAD TAR
LASTS LONGER

ROAD TAR AND PAVING PITCH. ALL SPECIFICATIONS.

Lewis Road Tar "A": For Hot Surface Treatment.

Lewis Road Tar "B": For Cold Surface Treatment and Dust Laying.

Lewis Road Tar "X": A Binder under Penetration Method, also for Hot Patching.

Lewis Joint Filler: For Cracks in Concrete and other Pavements.

Lewis Cold Patching Tar: For use Cold in Patching and Mixing with Stone, Slag or Sand.

Also Quick Drying Black Marking Paint, Waterproofing Compounds, Creosote Oil of all specifications, and Tar Primers for Bridge Floors.

The F. J. Lewis Manufacturing Company has been established since 1887, and during this period has enjoyed a steady and healthful growth and today, after forty years of progress, it is one of the foremost institutions in the successful processing and manufacturing of **coal tar** products.

Send inquiries for prices and all information to General Office at 2500 S. Robey St., Chicago, Ill., or to Newark, N. J., Office, 200-300 Doremus Ave., Newark, N. J., or to Mr. G. W. Shelly, Ohio representative, Thornville, Ohio.

Part of the Lewis fleet of modern distributors ready for application.

DU RO ASPHALT PRODUCTS COMPANY, INC.

Chamber of Commerce Building, Chicago, Ill.

Asphalt Paving Products

Products: ASPHALT PAVING CEMENT, ASPHALT FILLER, ROAD BINDERS, ROAD OILS, ASPHALT COLD PATCH.

Do Ro Asphalts are produced from selected Mexican crude, and are refined, without blending or mixing, by direct process to the desired penetrations. They contain in excess of 99¾ per cent pure bitumen, are highly ductile, and consequently afford best cementing qualities and lowest susceptibility to climatic changes.

Du Ro Asphalts are offered in grades ranging in penetration from 30 to 250. Each grade is especially designed and prepared for the use for which it is intended, and with the wide penetration range there is a grade for every type of road construction.

Du Ro Filler is designed particularly for Granite Block and Brick pavements, and for the sealing of joints and cracks in concrete pavements. This material is a blown asphalt with high melting point and unusually low susceptibility to temperature changes. It conforms to the specifications of the National Paving Brick Manufacturers Association, and other high grade specifications for this class of material.

Du Ro Cold-Patch is ideally adapted for the patching and repair of bituminous pavements, railroad crossings, and bridge roadways. It is applied cold and is prompt drying.

Du Ro Road Oils for the surface treating of gravel and macadam roads are made for both hot and cold application. They vary in asphaltic contents from 50 to 80 per cent.

Shipments: Shipments can be made immediately. Made in tank cars, and carload in metal drums, or wooden barrels.

Cooperative Service: Quotations supplied on application. Information respecting standard specifications and details regarding practice furnished on request.

Du Ro Filler Used with Granite Block

AEROIL BURNER COMPANY, INC.

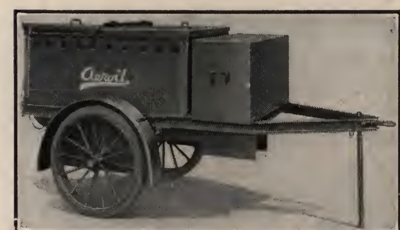
Park Avenue and 13th Street, West New York, N. J.

Portable Oil Burning Equipment for Street, Road and Highway Work

Products: "SMOKELESS" ASPHALT HEATING KETTLES, ASPHALT KETTLE TRAILERS, PATROL PATCHING HEATERS, PAVEMENT TOOL HEATERS, ASPHALT SURFACE HEATERS, PORTABLE LEAD MELTING FURNACES, SEWER COMPOUND MELTING POT, OIL-BURNERS FOR ASPHALT KETTLES, PORTABLE WATER HEATERS, CONCRETE HEATERS, FOR MIXERS, THAWING OUTFITS AND TORCHES, PORTABLE SAND DRYERS.

Aeroil TRADE MARK REG.

Aeroil "Smokeless" Asphalt Kettle Trailer



Aeroil "Smokeless" Asphalt Kettle Trailer with lock box cover

"Smokeless" Asphalt Heating Kettles and Kettle Trailers: These oil-fired kettles melt and heat bituminous materials such as pitch, asphalt or tar in one-half the time required with wood-burning kettles. Perfect temperature control, easy portability, longer life, quick starting and heating are the features which place Aeroil Kettles in a class by themselves. Hot stuff can be drawn within ten minutes after starting the oil burner. Made on legs, steel wheels or as a **trailer with rubber tires, leaf springs and roller bearings.** Made in the following sizes: 25, 50, 65, 75, 100, 110, 150 and 165 gallon capacity. Also made in 300 and 500 gallon capacity. The ideal kettle for pouring cracks and joints in concrete pavements. Fully described in our Bulletin No. 68.

Illustration No. 1

Oilburners for Asphalt Kettles: Woodburning asphalt kettles can be made "smokeless" by using Aeroil Kerosene Burners and Torches. They fit under most standard kettles and increase their efficiency and melting capacity 50 per cent.

Illustration No. 1 shows a No. 3 Aeroil Double Burner Outfit used under a 500 gallon woodburning kettle on a street repair job.

Illustration No. 2—a No. 13 Aeroil Double Torch Outfit in use under a 500 gallon Asphalt Kettle engaged in highway work. For full particulars ask for Bulletin No. 66.

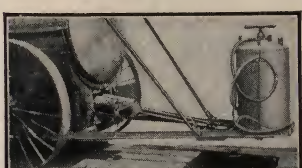


Illustration No. 2

Patrol Asphalt Patching Heater: Equipped with a 10 gallon pouring pot and a three gallon Burner Outfit. Recommended for patching asphalt, brick, granite, concrete, stone or wood-block pavements. Very compact and easily portable. Heats twice as fast as wood.

Full particulars in Bulletin No. 68.

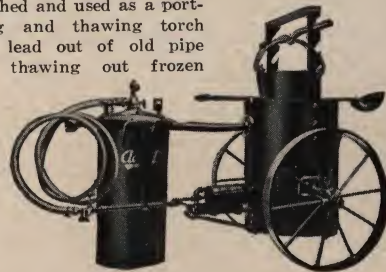
"Smokeless" Lead Melting Furnace—Portable Type on Wheels: The ideal lead melting furnace for pipe line laying or repair work. One of the outstanding features of this Furnace is that the burner may be detached and used as a portable heating and thawing torch for melting lead out of old pipe joints, for thawing out frozen ground, melting ice and snow, etc. Made in three sizes:

No. 18W melting pot capacity 200 lbs.

No. 24W melting pot capacity 450 lbs.

No. 30W melting pot capacity 850 lbs.

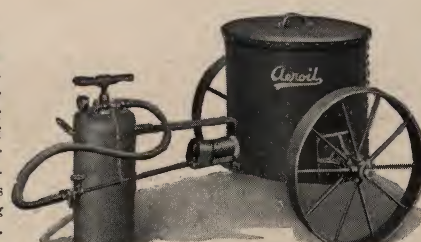
Furnished also on legs. Send for circular No. 64.



Combination Melting Furnace and Torch Outfit: For melting lead, babbitt, spelter or other soft metals. Melts 200 lbs. of lead in ten minutes. The Thawing Outfit is easily detached and can be used for many heating and thawing operations.

Fully described in Bulletin No. 64.

"Smokeless" Compound Melting Pot on Wheels: Especially designed for melting and heating pipe compounds of all kinds. Burner Outfit may be detached and used as a portable heating and thawing torch.



Made in three sizes:

No. 15 melting pot capacity 15 gallons.

No. 25 melting pot capacity 25 gallons.

No. 50 melting pot capacity 50 gallons.

Fully described and illustrated in Bulletin No. 64.

Aeroil Kerosene Torches: Gives steady, clean, intense heat. Used for drying out street openings, patching asphalt pavements, melting lead out of pipe joints, heating iron pipes for bending, thawing out frozen water, air and steam pipes, hydrants, taking the frost out of ground, melting ice and snow on manhole covers and many other heating and thawing operations. For full details ask for Bulletin No. 66.

Concrete Heaters: Easily attached to almost any type or size concrete mixer. Quickly heats aggregates to 90° F.—even in zero weather. Indispensable for winter concreting. Ask for Bulletins No. 60 and No. 62.

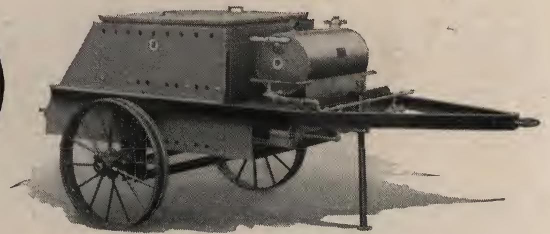
LITTLEFORD BROS.

475 East Pearl St., Cincinnati, Ohio

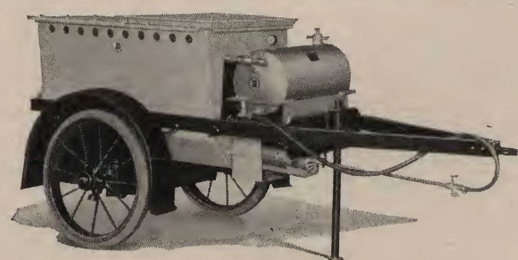
Road Maintenance Equipment

REPRESENTATIVES IN PRINCIPAL CITIES

Products: Tar and Asphalt Heaters—10 to 1,500 Gallons Capacity, Sand and Gravel Driers, Oil Burning Outfits, Concrete Heaters, Grout Mixers, Tool Heaters, Surface Heaters, Tool Houses, Squeegee Machines, Asphalt Paving Tools, Asphalt Pouring Pots, Traffic Line Markers, Powder Storage Magazines. Catalog on Request.

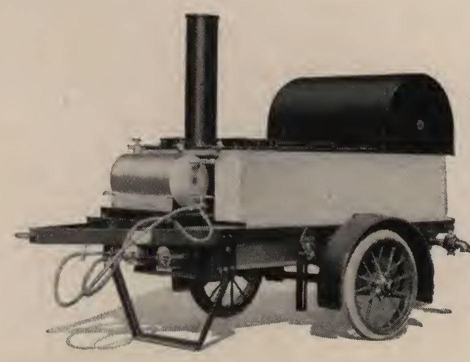


No. 84-W: This Oil Burning Asphalt Kettle embodies all that road and street maintenance superintendents are looking for. Because of its sturdy construction it will stand up under the worst kind of usage—spring cushioned axle, roller bearing wheels, and rubber tires (if desired), make No. 84-W a fast trailing outfit. Other features are: Trouble proof, quick heating, torch-type burner, non-clogging strainer in melting tank, and a no-drip draw off cock. Four capacities: 50, 75, 110 and 165 gallons.

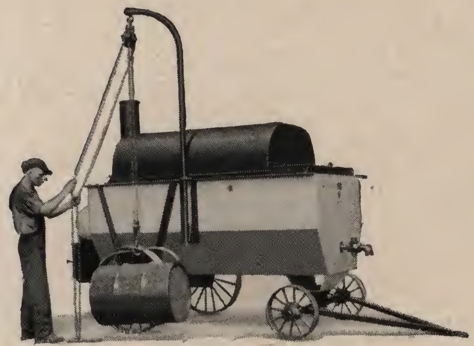


No. 48: Contractor's Special, two capacities, 300 and 550 gallons. The melting tank is made of ¼″ special analysis fire box steel. This heater will melt an entire batch of asphalt within two or three hours. The draw off cock will not clog—a large strainer placed at the front end of the melting tank prevents any solid matter from getting near the cock. The running gear is equipped with heavy duty roller bearings; axles are made of high carbon steel. Warming hood shown on No. 83 can also be used on this heater. Rubber tires and heat guards optional.

No. 90: This combination Oil Burning Tool Heater and asphalt melting kettle is unsurpassed for efficient street repair work. It is especially suited to the needs of cities and towns. The three Littleford burners, with which this heater is equipped, will heat 15 tools within five minutes. The asphalt kettle has a capacity of 50 gallons. One man can easily handle and operate this heater. Steel wheels standard equipment; rubber tires and heat guards optional.



No. 78-OB: This is the Littleford large capacity Oil Burning Trail-O-Heater. 300 gallons of hot tar or asphalt can be quickly and conveniently moved to widely separated jobs. For county and state highway maintenance No. 78-OB is the ideal heater. Hot asphalt can be drawn from it in 30 to 40 minutes. The heating unit consists of two Littleford torch type oil burners. The bottom of the combustion chamber is lined with 1 in. Sil-O-Cel asbestos block insulation which retains the heat produced by the burners. Rubber tires and heat guards are standard equipment on this heater. No. 78-OB has a wood and coal burning mate—No. 78.

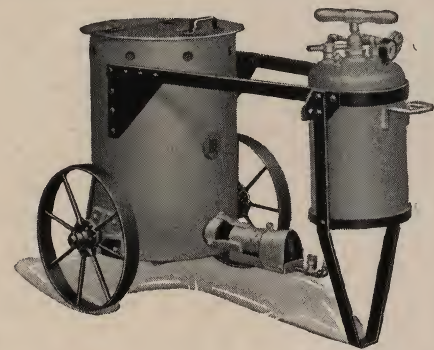


No. 83: 300 and 550 gallon Oil Burning Asphalt Heater. Two torch-type Littleford Burners are the heating unit. The bottom of the furnace shell is lined with 1 in. Sil-O-Cel block insulation, thereby retaining all heat within the furnace. Rubber tired wheels and heat guards optional. Warming hood shown aids greatly in draining barrels of material—it is optional. Barrel hoist, an accessory for any Littleford heater, can be quickly attached.

Portable Tool Box: 49 in. wide, 8 ft. long. Two hinged lids form a waterproof cover—a 12 in. shelf running through the center of the box provides a convenient place for smaller tools. Wheels equipped with rubber tires and Timken roller bearings. The axle is mounted on semi-elliptical springs.

No. 69: A wood and coal burning Maintenance Heater of popular size, made in three capacities: 60, 110 and 165 gallons. A very efficient outfit. Steel wheels standard equipment; rubber tires and heat guards optional.

This Heater, equipped with the Littleford Hand Spraying Attachment as shown, is ideal for penetration work on small patches and small construction jobs. The Hand Spraying Attachment can be adjusted to all makes and sizes of heaters.



No. 68-OB: This 10 gallon capacity Oil Burning Patrol Heater is made for small patch work and for keeping expansion joints filled. It weighs only 175 pounds. The wood and coal burning Patrol Heater is No. 68.

Oil Burners: Littleford Portable Oil Burners, either torch-type or circular, are trouble proof. Controlled by a simple valve adjustment, they can be easily regulated to a simmering flame or a roaring blaze.

No. 12: The Littleford Sand and Gravel Dryer is simple in construction and rapid in supplying dry sand or gravel. It has a capacity of 32 cubic feet—the wet stand is thrown into the heater from the top onto an arched plate to which it clings. The fire box supplies intense heat the full length of the dryer. As the sand dries it slips from the arched plate to side ledges from which it can be shoveled as needed.

E. D. ETNYRE & CO.

81 Jefferson St., Oregon, Ill.

Manufacturers of Road Oilers (Hot and Cold) Street Sprinklers and Flushers

Products: Street Flushers, Street Sprinklers, Bituminous Distributors.

Model "F" Distributor: The Etnyre Model "F" Distributor is a complete and self-contained unit for heating and distributing any and all grades of Oil, Tar and Asphalt used for road construction and maintenance.

It is of the direct pump pressure type on which the pump is driven by a separate motor furnished in eleven standard tank sizes for mounting on any make of motor truck.

It will fill the tank with its own power, pump material from one tank to another, heat rapidly, circulate the material while heating, apply material accurately and uniformly in any quantity and any width up to 20 feet.

Standard Equipment

Tank—500 to 1,200 gallon, with or without insulation.

Engine—15 horsepower.

Complete Fuel and Heating System. Including two burners.

Spray Bars—2 4-ft. sections with nozzles (other widths up to 20 ft. optional at additional price).

Snap Union Connections—3 in. for attaching flexible tubing for filling tank, and 2 in. for attaching spray bars.

Brackets—With eccentric levers for carrying spray bars when traveling back and forth to supply tank.

Fenders for the rear wheels of the truck.

Running Board on left side.

Tool Box—12x14x83 in. (Forms running board on right side.)

Pump Warming Attachment including portable burner.

Operator's Seat and Platform.

Complete Set of Strainers. (Strainer for manhole furnished only when ordered.)

Complete Set of Tools, Service Parts and Bolts for Fastening to Truck.

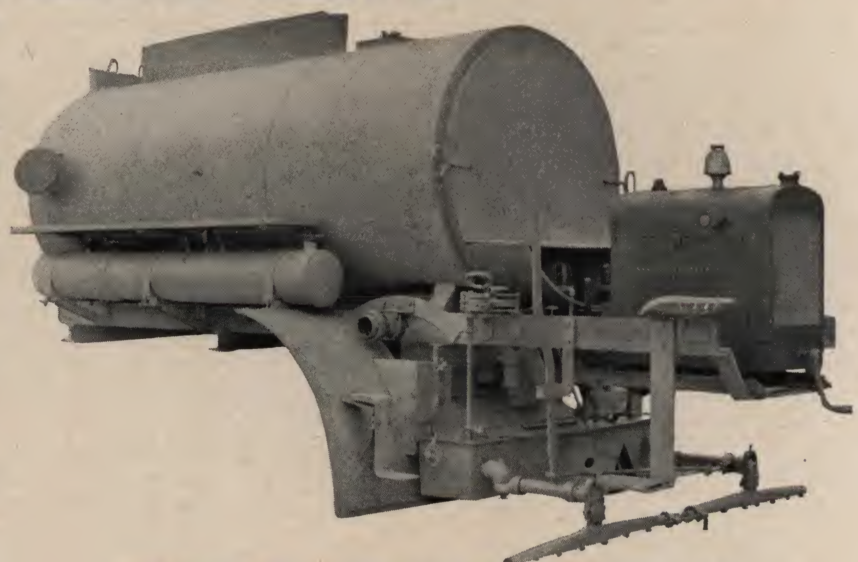


Illustration shows distributor with insulated tank covering and with shifting attachment in addition to standard equipment

Model "G" Distributor: On our Model "G" Distributor the pump is driven from the power take-off on the transmission of the truck. It is furnished with drive chain, sprockets and shafting for connecting the pump to the take-off shaft instead of the motor.

SPECIFICATIONS—DIMENSIONS—WEIGHTS

Standard Tank Sizes, "Model F," Separate Engine-Driven Pump Type

No.	Tank				Frame		*A	Weight		
	Net Cap. Gallons	Diameter Inches	Length Inches	Gauge Steel	No. of Cradles and Bands	Length of Sills	See Outline Drawing Below, In.	Without Insulated Covering	With Insulated Covering	With Covering and Full Tanks
4	500	43⅝	90	No. 10	3	13′	70 to 76	4800	5300	9550
4-A	550	43⅝	102	No. 10	3	14′	76 to 82	5000	5525	9925
5	600	43⅝	108	No. 10	4	14′ 6″	82 to 88	5100	5650	10700
5-A	630	43⅝	114	No. 10	4	15′	88 to 94	5175	5750	10790
6	650	43⅝	120	No. 10	4	15′ 6″	94 to 102	5240	5840	11290
7	800	48	114	No. 7	4	15′	85 to 92	5560	6160	12810
8	850	48	120	No. 7	4	15′ 6″	92 to 98	5625	6275	13325
9	900	48	126	No. 7	4	16′	98 to 106	5690	6390	13840
10	1000	52	120	No. 7	4	15′ 6″	94 to 102	5660	6360	14610
11	1100	52	132	No. 7	4	16′ 6″	104 to 112	5860	6610	15660
12	1200	52	144	No. 7	4	17′ 6″	112 to 120	6060	6860	16710

HAUCK MANUFACTURING COMPANY

Established 1900

110 Tenth Street, Brooklyn, New York

Oil Heaters and Torches

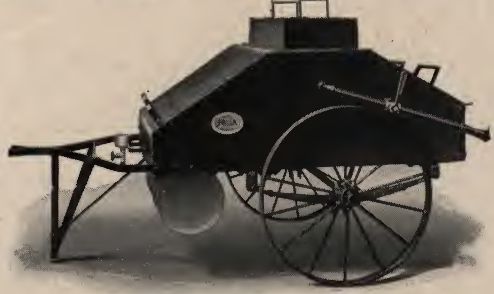
Products: ASPHALT SURFACE HEATERS, ASPHALT TOOL HEATERS, CIRCULAR FLAME BURNERS FOR HEATING KETTLES, HEATERS FOR CONCRETE MIXERS, THAWERS; KEROSENE BURNERS AND TORCHES; WEED BURNERS.

Hauck Kerosene Oil Burners and Heaters—Every item shown here is successfully used by contractors, municipal and state highway departments. Simple construction and proper design enable unskilled operators to secure excellent results.

Asphalt Surface Heater and Patcher

Asphalt Heater and Patcher—It has been designed and constructed with the co-operation of asphalt highway officials. *"It removes ridges and high spots in bituminous coverings of surfaces at less cost than cutting them down by the use of mattocks, etc. In fact, two men with a double burner heater can do as much work as ten men by the old method."* Burners operate with kerosene and are absolutely dependable. Send for bulletin No. 131 and performance data.

No.	Hood	Tank Capacity	No. of Burners	Oil Cons. Per Hour	Net Weight	Length
485	28"x48"	1 25-gal.	2	2 gal. ea.	460 lbs.	11'2"
487	48"x72"	2 25-gal.	3	3 gal. ea.	480 lbs.	14'6"



Kerosene Tool Heater

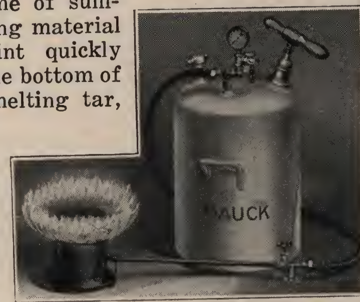
Hauck Kerosene Tool Heater—Heavy Steel plate construction, perfect balance, long life. Tools heated withing 15 minutes of starting. *"A Hauck Tool Heater saves $455.40 per year, which more than repays first cost."* Operates satisfactorily in all kinds of weather. Furnished with rubber-tired wheels if desired. Weight, 1,210 lbs.; length, 102 inches; width, 63 inches; height, 54 inches; diameter of wheel, 36 inches; two burners, consumption per burner, 1½ gal. per hour. Capacity of kerosene tank, 25 gal. Send for bulletin No. 1005 and performance data.

Hauck Weed Burners (Kerosene) burn back the weeds the prescribed legal distance from the highway. Two to three burnings a year will control weeds—because it kills the seeds. Send for bulletin No. 1013.

Hauck Kerosene Burners and Torches—for burning off high spots on asphalt pavements, drying brick pavements, etc., and general heating and repair work. Send for bulletin No. 2001.

Hauck Circular Flame Burner Outfit—This burner produces a circular flame of sufficient intensity to bring material to the melting point quickly without damage to the bottom of kettles. Ideal for melting tar, pitch, asphalt, etc.

Brass pump inside tank secures 40-50 lbs. pressure in a few minutes which will operate burner for several hours.



Circular Flame Oil Burner

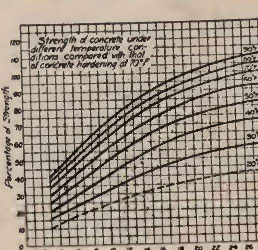
Sizes as follows:

No.	Capacity of Tank	Length of Hose	Heighth of Burner	Oil Cons. Per Hour	For Kettles up to
70	3 gal.	6 ft.	6½ in.	¾ gal.	25 gal. cap.
71	5 gal.	6 ft.	7½ in.	1 gal.	50 gal. cap.
72	12 gal.	6 ft.	10 in.	2 gal.	100 gal. cap.
73	12 gal.	12 ft.	12 in.	3 gal.	150-200 gal. cap.

Any one of the above burner equipments can be furnished with larger tanks of 15 and 20-gal. capacity. Also Double Burner Units (two burners operating from the same tank) can be obtained. Send for bulletin No. 1007.

Hauck Heaters for Concrete Mixers—Approved by highway officials. Heats aggregates and water during mixing at almost summer speed, and very economically. Temperature of the mix can be raised to 90 degrees Fahrenheit or higher, and rapid hardening allows setting before freezing. Work should be protected with tarpaulins.

Mixer with No. 90 Hauck Heater



Effect of Temperature on Concrete.

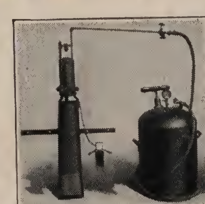
When the average temperature is below 40 degrees Fahrenheit, the material should be heated. Hot mix retains the heat for 48 to 64 hours during setting. The strength of concrete work increases as shown by the diagram by the Portland Cement Association.

Heaters regularly made in two sizes as shown below:

No. 80—For Concrete Mixers up to 10 ft. materials. Burner consumes 2 gallons kerosene per hour. Capacity of oil tank, 15 gallons, furnished with 12-ft. length of oil hose. Shipping weight, 110 lbs.

No. 90—For Concrete Mixers larger than 10 ft. up to ¾-yard material. Burner consumes 2½ to 3 gallons kerosene an hour. Capacity of oil tank, 20 gallons, 12-ft. length of oil hose furnished. Shipping weight, 135 lbs.

State make, size or capacity of mixer, method of charging and discharging, when ordering a Hauck Heater.



Concrete Heater

THE JOS. HONHORST CO.

1016-20 West Sixth Street, Cincinnati, O.

Manufacturers of Tar Heaters

Products: Tar Heaters, Portable and Stationary, Sand Driers, Tool Heaters, Oil Burners, Smokestacks, Tanks and General Steel Plate Work.

Heavy Duty Tar Heater: A heater of large capacity made of heavy plate steel. The kettle is welded leak proof and is set in a firebox of ample proportions. The wheels and axles are all steel. This is a very rapid heater and is admirably suited for large contracts on roads or streets, or any place where tar or asphalt compounds are used in large quantities.

Sizes 250, 350, 500, 700 and 900 gal.

Style E Tar Heater: A very rapid heater superior to any other of like capacity on the market. It is especially well designed for heating material to a very high temperature, because the kettle is completely surrounded by the firebox. An ashpit below the grates catches all ashes and live coals.

This heater mounted on plain steel wheels, steel wheels with roller bearings, or steel wheels with roller bearings and rubber tires.

Sizes 65, 110, 165, 200 gal.

Style A Tar Heater: For heating compounds that do not require exceedingly high temperature. The kettle has a flat bottom, a hinged cover, and a 2 in. drawoff valve. The firebox is formed by extending the kettle shell. It has a cast-iron grate, hinged firedoor, cast-iron smokestack nozzle and steel stack. Mounted on plain steel wheels, steel wheels with roller bearings, or on steel wheels with roller bearings and rubber tires.
A sturdy well built heater suitable for roofing or road repairs.

Sizes 50, 75, 100, 125 and 150 gal.

Oil Burning Heater: A modern heater for road work. Heats quickly and economically. Perforated division plate keeps the cold lumps of material separate. The oil burner can be easily removed and used independently. This heater mounted on plain steel wheels, steel wheels with roller bearings, or steel wheels with roller bearings and rubber tires.

Sizes 65, 110 and 165 gal.

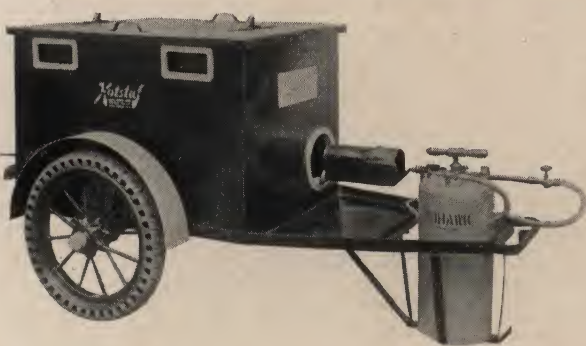
MOHAWK ASPHALT HEATER CO.

56 Weaver Street, Schenectady, N. Y.

Manufacturers of "Hotstuf" Asphalt Heaters

Products: "HOTSTUF" ASPHALT HEATERS, OIL BURNER OUTFITS, MOHAWK SEPTIC TANKS, STORAGE TANKS, METAL MORTOR BOXES.

The "Hotstuf" Asphalt Heater for Streets, Highways and General Construction. The Hotstuf Asphalt Heater is especially adapted for road contractors, state highway and city street departments. This heater has approximately double the melting capacity of the old style wood burning



kettle, and eliminates the smoke nuisance and fire hazard.

The 50 gallon Heater mounted on wheels is especially suitable for patrol work, patching, filling cracks, and resurfacing, and is very economical and convenient to operate.

New Improved Oil Burner: The new improved Mohawk oil burner with removable coil saves the cost of a new burner, and is designed especially for the economical use of oil fuel.

Exclusive Elevated Melting Chamber produces immediate and continuous supply of Hotstuf with perfect temperature control.

The Hotstuf Heater is positively the cheapest operating heater that money can buy, because the Hotstuf heater will give you more hot material per dollar of fuel and labor than any other heater on the market.

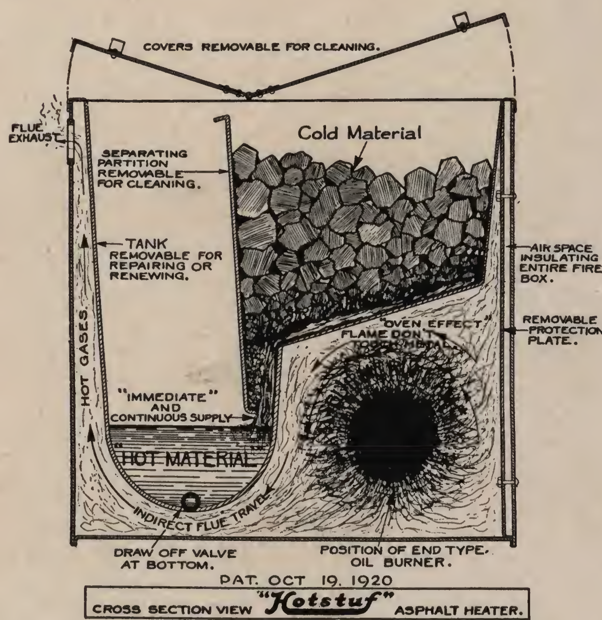
It is a time saver. Light the heater when the crew arrives on the job. You have hot tar in five minutes—hot asphalt in ten minutes. No overtime for heater man.

The Heating Unit: Can be used separately as a torch for heating concrete, water or thawing.

It is the simplest to maintain. The parts are so few and so simple in construction that there is nothing to go wrong—can be replaced, when worn out, at very little cost.

It is the most convenient. Take it up on the roof—down in the basement—subways—streets—anywhere. There is no smoke—no sparks—no troublesome expensive sand box—no special fire precautions.

No more carting of wood. No more dipping. The hot material is drawn off through a valve. It is easily handled. It is not necessary to empty the heater in order to move it.



CROSS SECTION VIEW "Hotstuf" ASPHALT HEATER.

Exclusive Elevated Melting Chamber Design Produces Hotstuf 30% Faster With 30% Less Oil.

Capacity

50-Gal. Hotstuf Heater, approximate melting capacity 5,000 lbs. Asphalt in 8 hours. Coal tar pitch 7,000 lbs. in 8 hours.

Fuel consumption approximately 1 gal. kerosene per hour.

Storage capacity of Hotstuf 1 barrel.

Dimensions

Mounted on wheels:
Over-all width 37 inches.
Over-all length 72 inches.
Approximate shipping weight on legs 350 lbs.; complete; on wheels 500 lbs. complete.

Capacity

100 Gal. Hotstuf Heater, approximate melting capacity 8,000 lbs. Asphalt in 8 hours. Coal tar pitch 10,000 lbs. in 8 hours.

Fuel consumption approximate $1\frac{1}{2}$ gal. kerosene per hour. Storage capacity 2 barrels of Hotstuf.

Dimensions

Mounted on wheels:
Heater width 36 inches.
Heater length 50 inches.
Over-all width 51 inches.
Over-all length 89 inches.
Approximate shipping weight 750 lbs. complete.

Steel tires standard equipment. Rubber tires and roller bearing prices on request.

Cable Address
Bitulithic Boston

WARREN BROTHERS COMPANY

P. O. Box 1869, Boston, Mass.

Manufacturers of Asphalt Paving Plants and Equipment and Asphalt Pavements

DISTRIBUTING OFFICES
New York City, 50 Church Street   Chicago, Ill., 10 So. La Salle Street

Products: Asphalt Paving Plants, Asphalt Paving Plant Separate Units and Asphalt Street Paving and Repair Work.

Warren's Composite Type Asphalt Storage and Heating Tank and **Pumping Outfit** embodies one of the greatest recent advances in the method of handling, storing and heating asphalt for use in asphalt paving mixtures.

The employment of this tank permits the use of tank car material, which procedure in itself results in a saving of approximately 20% in the first cost of the asphalt; it makes possible an appreciable saving in expense of handling the material at the plant; it results in a general improvement in surroundings and working conditions, and permits the elimination of intermediate heating tanks with a consequent saving in equipment first cost which practically covers the cost of the storage tank. A considerable saving of ground space is effected by the employment of this tank, which space can ofttimes be devoted to other and more profitable purposes; it also represents an excellent insurance, at a relatively low premium rate, against delayed plant operation and street work due to shortage of asphalt, and further results in a considerable saving on demurrage charges ordinarily consequent to the employment of tank car material.

Together with the tank there is furnished a steam-jacketed twin gear asphalt pump, direct connected to a high grade vertical steam engine, both of which are mounted as a unit on a cast iron base. Steam heated asphalt piping conveys the asphalt from the pump to the storage tank and there is also provided a steam heated suction line from the central heating compartment of the storage tank to the asphalt pump.

The high ratio of heating area in the central chamber combined with the employment of a Patented Rapid Discharge Tube enables the start of pumping operations in from one to one and one-half hours after steam is first turned onto the coils. This arrangement provides an ample and uninterrupted supply of asphalt at all times, melted and heated to a temperature necessary for its use in the paving mixture. A pronounced saving in fuel consumption is made possible by the fact that only the relatively small volume of asphalt in the central heating chamber is kept constantly hot, this being replaced as used by the bulk material which flows into the bottom of the heating chamber from the surrounding bulk storage.

These tanks are built in three sizes, to wit: 25,000, 33,500 and 60,000 gallons respectively. They are designed with bolted connections which permit of their being readily dismantled and shipped to a new site, the shell segments being of a size which will permit shipping them on a railway car. So practical and economical have these tanks proven that they have become standardized by many contractors and municipalities throughout the country.

A completely illustrative descriptive circular will be forwarded upon request to interested inquirers.

Composite Type Asphalt Storage and Heating Tank and Steam Heated Asphalt Pumping Outfit.
This Storage and Heating Tank is equipped with Patented Rapid Discharge Tube protected by U. S. Letters Patent, date of June 12, 1926, granted to Horace W. Ash. Other patents pending

Granite Block Pavement

Specifications American Society of Municipal Improvements.

Standard Specifications for Stone Block Paving

1. Description.—This pavement shall consist of stone blocks and sand cushion, or cement-sand bed paved on the previously constructed concrete base course. The type of block and character of joint filler and material for the cushion or bed shall be as designated in the proposal.

New Granite Blocks

2. Quality of Granite.—The blocks shall be of granite of medium-size grain, showing an even distribution of constituent minerals. They shall be of uniform quality and texture throughout, and free from seams or disintegrated materials.

The quality of granite shall conform to the requirements for Class A or Class B, for extra heavy or heavy traffic respectively, as designated in the proposal:

Class A—
French coefficient ....Not less than 11
(Percentage of wear..Not more than 3.6)
Toughness ....Not less than 9

Class B—
French coefficient ....Not less than 8
(Percentage of wear..Not more than 5.0)
Toughness ....Not less than 7

The average of three tests shall be used for determining both the percentage of wear and toughness.

3. Size and Dressing of Blocks.—The blocks shall be of the following dimensions: Not less than eight (8) nor more than twelve (12) inches long on top; not less than four and three-quarters (4¾) nor more than five and one-quarter (5¼) inches deep; and the width on the top shall be either three and one-half (3½) to four and one-half (4½) inches, or four and one-half (4½) to five and one-half (5½) inches.

The blocks shall be so dressed that the faces will be approximately rectangular in shape, and the ends and sides sufficiently smooth to permit the blocks to be laid with joints not exceeding one-half (½) inch in width at the top, and for one (1) inch downward therefrom, and not exceeding one (1) inch in width at any other part of the joint. The top surface of the block shall be so cut that there will be no depressions measuring more than three-eighths (⅜) of an inch from a straight edge laid in any direction on the top and parallel to the general surface thereof.

Resurfacing Blocks

4. Size and Character.—Resurfacing blocks for use on old concrete foundations where less than the standard depth of blocks must be used, shall be seven (7) to eleven (11) inches long, three and three-quarters (3¾) to four and one-quarter (4¼) inches wide and three and one-half (3½) to four (4) inches deep, and shall in all other respects meet the requirements as to quality and dressing for new granite paving blocks.

New Sandstone Blocks

5. Quality, Size and Dressing.—The paving blocks shall be of sound, hard sandstone, free from clay, seams or defects which would injure them for paving purposes, of uniform quality and texture.

They shall be quarried from fine grained live rock, showing a straight and even fracture, and shall be made by splitting and breaking from large quarried blocks and not by redressing old paving blocks.

The blocks shall be of the following dimensions: not less than eight (8) nor more than ten (10) inches long; not less than three and one-half (3½) nor more than five (5) inches wide on top; not less than five (5) nor more than five and one-half (5½) inches deep.

These blocks shall conform in character of dressing to the requirements for granite blocks in Section 3.

Durax Paving Blocks

6. Quality, Size and Dressing.—Durax paving blocks shall be cut from granite complying with the requirements specified herein for new granite paving blocks.

The blocks shall be cubes of granite with six (6) approximately square surfaces, the edges of which measure not more than four (4) nor less than three (3) inches in length. They shall be dressed so as to conform with the requirements specified for new granite blocks, except as to form and dimensions.

7. Method of Paving.—They shall be laid as specified for new granite blocks, except that the courses shall be laid in circular concentric arcs with the largest blocks at the center of the arc and the smaller ones at the springing line. The radii of the arcs may be varied from three (3) to seven (7) feet.

Sampling and Inspection of Blocks

8. Preliminary Samples and Certificates.—Contractors shall file with the Engineer at or before the time of bidding a certificate showing the name and location of the quarry or quarries from which it is proposed to obtain the blocks, together in the case of granite blocks, with a copy of a report or reports from an approved laboratory showing results of tests for toughness and per cent of wear. The contractor shall further file with the Engineer prior to the letting six (6) specification blocks representing the stone proposed for use, except that such samples will not be required where a previous sample of the same blocks has been filed and approved.

9. Sampling and Inspection of Shipments.—Samples selected from shipments for physical tests by the Engineer or his representative shall consist of not less than six (6) blocks so chosen as to fairly represent actual deliveries. No samples shall include blocks that would be rejected by a visual examination and the bedding plane shall be marked on at least two of the blocks selected.

All deliveries shall be subjected to further inspection at the place of use prior to and during laying and blocks which fail to conform to the requirements of these specifications shall be rejected.

10. Materials for Cement-Sand Bed.—Cement-sand bed shall consist of one part Portland cement and four parts by volume of clean, coarse sand, well-graded from a maximum size of one-quarter (¼) inch particles.

11. Materials for Grout Filler.—Grout joint filler shall consist of one part Portland cement and one part by volume of clean, sharp, well-graded, fine sand, free from particles of such size as to obstruct the ready flow of the grout to the bottom of the joints.

12. Materials for Bituminous Mastic Filler.—Bituminous mastic filler shall consist of a combination of approximately equal parts by volume of sand with one of the bituminous materials hereinafter specified.

A. Sand. Sand for bituminous mastic filler shall consist of clean, durable grains of which all shall pass a standard 10-mesh sieve and 85% by weight shall pass a 20-mesh sieve.

B. Tar Pitch Filler. The coal-tar pitch shall conform to the following requirement; tests to be made on the sample as received, but results reported on a dry basis. The softening point shall have a range of not more than 10° F. within the limits below given, as may be directed.

(*a*) Water..0.00 per cent
(*b*) Softening point (Cube-in-Water Method) 46 to 57° C. (115 to 135° F.)
(*c*) Distillation test:
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)..not more than 10.00 per cent
Residue, by weight..not less than 90.00 per cent
(*d*) Specific gravity at 25°/25° C. (77°/77° F.) of total distillate to 300° C. (572° F.)....................not less than 1.03
(*e*) Softening point (Cube-in-Water Method) of residue from distillation test............not more than 75° C. (167° F.)
(*f*) Ductility at 50 to 100 penetration, at 25° C. (77° F.)..not less than 50 cm.

NOTE.—The penetration of the pitch shall be brought within the range of 50 to 100 penetration by heating in an open vessel with frequent stirrings at a temperature of not over 350° F.

(*g*) Total Bitumen (Soluble in Carbon Disulfide)..65.00 to 80.00 per cent

C. Asphalt Cement Filler. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec..............60 to 70
(*b*) Flash point (open cup)............not less than 175° C. (347° F.)
(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr. ....not more than 2 per cent
Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..not less than 60 per cent
(*d*) Ductility at 25° C. (77° F.)........................not less than 30 cm.
(*e*) Proportion of bitumen soluble in carbon tetrachloride ....not less than 99 per cent

D. Tar and Asphalt Filler. This material for use in bituminous mastic filler shall be a mixture of coal-tar pitch and refined asphalt, consisting of 100 parts of coal tar and 20 parts of refined asphalt. These products shall comply respectively with the requirements of Sections 12B and 12C, except that the penetration of the asphalt at 77° F. shall be not less than 30 nor more than 40.

Construction Methods

13. Care in Handling Blocks.—Care shall be exercised in handling the blocks so that the edges and corners shall not be chipped or broken, as blocks otherwise acceptable may be rejected on account of spalling.

14. Sorting Blocks.—The blocks shall be sorted and laid in courses of uniform width, except in special cases, as may be ordered. The stone from each quarry shall be piled and laid separately in different sections of the work, and in no case shall the stones from different quarries be mixed.

15. Cushion or Bed.—On the previously constructed concrete base course shall be spread a layer averaging one (1) inch in depth of sand cushion or of a mixture of one (1) part cement and four (4) parts sand for cement-sand bed as designated in the proposal.

16. Laying the Pavement.—Upon the sand cushion or cement-sand bed the blocks shall be laid in courses at right angles to the line of the street, and in a straight line from curb to curb, except in special cases, when they shall be laid at such an angle as may be directed by the Engineer. The blocks shall be laid as closely as possible, each block touching the adjoining one on sides and ends, and in courses of uniform width. All joints shall be broken with a lap of at least three (3) inches. The blocks shall not be laid more than twenty-five (25) feet in advance of the ramming. After the blocks are laid, they shall be rammed to a solid bearing, the joints shall be adjusted, all unsatisfactory blocks shall be taken out with tongs and all low blocks shall be raised to an even and

true surface. Pinch bars shall not be used, except by special permission of the Engineer, and no sand shall be placed in the joint except when mixed with the filler specified in the proposal.

17. Applying Bituminous Mastic Filler.—Bituminous mastic joint filler shall consist of bituminous material complying with one of the sets of requirements in Section 12, unless otherwise indicated in the proposal, thoroughly mixed with as much hot, dry sand as the bituminous material will carry, but in no case shall the volume of sand exceed that of the bitumen. The sand shall be heated to a temperature of not less than 300° F., nor more than 400° F., and shall be between these limits when mixed with tar or asphalt. The bituminous material shall be heated in kettles, equipped with approved thermometers. Tar filler at the time of use shall have a temperature of 250 to 325° F., and asphaltic cement shall be used at a temperature of 275 to 350° F.

The mixture shall be flushed on the surface of the blocks and pushed into the joints with suitable tools, reflushed or repoured if necessary, until the joints remaining are permanently filled, flush with the surface of the pavement. As little as possible of the mixture shall be left on the surface.

In applying the filler, care shall be taken that the pavers are closely followed by the filler gang, and in no case shall the paving be left over night, or when work is stopped, without the filling of the joints being completed. In case rain stops the filler gang before its work is finished, the joints shall be protected by the use of tarpaulins, or other means to keep out water. Under no circumstances shall the filler be poured into wet joints.

18. Portland Cement Grout Filler.—Portland cement grout filler shall consist of one part Portland cement and one part of clean, sharp sand as hereinbefore specified. The cement and sand shall be thoroughly mixed in a batch mixer of approved type, using only enough fresh water to make a grout which will flow to the bottom of the joints and shall be applied to the joints before the ingredients have separated.

Prior to grouting the pavement shall have been brought to a uniform surface and the blocks shall be wetted. The grout shall be broomed or scraped into the joints if necessary to fill same and the operation shall be repeated as the grout settles and before the initial set has taken place until the joints are thoroughly filled, flush with the surface of the blocks. Immediately after this, the entire pavement shall be broomed to a smooth surface.

19. Protection of Surface.—After the grouting is completed and a sufficient time for hardening has elapsed so that a coating of sand will not absorb moisture from the cement mixture one-half (½) inch of sand shall be spread over the whole surface and shall be kept damp until the street is opened for traffic.

After the grouting is completed the street shall be kept closed and no carting or traffic allowed on any part of the grouted pavement until at least seven (7) days have elapsed.

Should the bond between the blocks become broken before the work is accepted, such defective work shall be regrouted or relaid and again protected as previously described.

Note 1. **Recut or Redressed Paving Blocks.**—Specifications for recut or redressed paving blocks may be formulated along lines parallel to those for new paving blocks. It is recommended that old blocks cut from stone complying with the requirements of these specifications as to quality shall be employed for this purpose. Requirements for dressing should be the same as those for new blocks, but the dimensions must be varied in accordance with the dimensions of the old blocks to be redressed.

Note 2. These specifications are so drawn as to include all well known forms of stone block paving, covering size, form and quality of block and character of cushion and joint filler. Since all of these variations would not be acceptable on any one project, the specifications for use in any given case must either be modified by eliminating materials which are not acceptable, or must be accompanied by a proposal clearly indicating the exact character of paving required.

Block for Granite, Recut Granite and Durax Granite Pavements

Proposed Master Specifications of U. S. Government

General Specifications.—There are no general specifications applicable to this specification.

Types and Grades.—The materials covered by this specification shall be supplied in the particular type (s) and grade (s) ordered by the purchasing department.

Type	Grade
Granite Block	Extra heavy traffic
	Heavy traffic
Recut Granite Block	Heavy traffic
Durax Granite Block	Heavy traffic

Material and Workmanship.—1. The blocks shall be of granite of medium size grain, showing an even distribution of constituent minerals. They shall be of uniform quality and texture throughout, and free from seams or disintegrated materials.

2. **Dressing:**

(a) The blocks shall be so dressed that the faces will be approximately rectangular in shape, and the ends and sides sufficiently smooth to permit the blocks to be laid with joints not exceeding ½ inch in width at the top, and for 1 inch downward therefrom, and not exceeding 1 inch in width at any other part of the joint.

(b) The wearing surface of the blocks shall show no depressions more than ⅜ inch in depth, and the edges and corners shall be unchipped and unbroken.

General Requirements.—No details specified.

Detail Requirement.—The respective types and grades shall meet the following requirements:

1. Physical properties, as determined by an average of three tests of sample blocks.

Type of Block		Granite	Recut Granite	Durax Granite
Grade Traffic	Extra Heavy	Heavy	Heavy	Heavy
Percentage of wear not more than	3.6	5.0	5.0	5.0
Toughness — not less than	9	7	7	7

2. Dimensions.

Type of Block	Granite	Recut Granite	Durax Granite
Length on top, inches	8 to 12	6 to 12	3 to 4
Width on top, inches	3½ to 4½	3½ to 4½	3 to 4
Depth, inches	4¾ to 5¼	4¾ to 5¼	3 to 4

Miscellaneous Block Pavement

Specifications Maryland State Roads Commission.

Paving Around Inlets. Wherever indicated on the plans, in conjunction with a bituminous or other pavement, a double row of new whole block of the character designated shall be laid around the grate frames or drip-stones of grate-top and open-mouth inlets, respectively, directly on the concrete before it has developed initial set, unless otherwise indicated or directed. The near edges of the blocks adjacent to the inlet structures shall be flush with the grate-top or drip-stone, from which point the surface of the blocks shall slope upward uniformly, at a rate of not more than one and three-quarters (1¾) inches to the foot, to the finished surface grade of the pavement. Spaces between the blocks shall not be less than one-eighth (⅛) nor more than one-half (½) of an inch in width, depending on the kind of block used, and the blocks shall be laid to break joints by not less than three (3) inches. The spaces between the blocks shall be filled as indicated. This paving shall be done with similar materials and in accordance with the specifications contained herein for the kind of blocks used, except as noted above. Where and whenever necessary, drip-stones shall be reset, without additional compensation, at such grade as will afford a uniform open-mouth of six (6) inches in general depth, except when directed otherwise.

Placing Railway Track Block Liners. Where indicated on the plans, in conjunction with a bituminous or other pavement laid adjacent to the tracks of a street railway, a double row of new whole block of the character designated shall be laid adjacent and parallel to each edge of each rail, directly upon the concrete foundation before it has developed initial set. The blocks shall be laid to meet the rail surface or to be slightly below, as indicated or directed. The rail shall conform to the established grade of the roadway. The blocks shall be backed thoroughly with concrete tamped carefully to a firm bed. Spaces between the blocks shall be not less than one-eighth (⅛) nor more than one-quarter (¼) of an inch in width, depending on the kind of blocks used, and the blocks shall be laid to break joints by not less than three (3) inches. The spaces between the blocks shall be filled as indicated. This paving shall be done with similar materials and in accordance with the specifications contained herein for the kind of blocks used, except as noted above.

Placing Railway Rail Channel Filler. Prior to laying any pavement or liners adjacent to a street railway track, the spaces between the web of the rail and the blocks shall be filled with cement mortar composed of one (1) part of Portland cement and two (2) parts of fine aggregate conforming to the requirements for "Plain Cement Concrete Base Course." The mortar shall be in a plastic condition and the exposed surface of the filling shall be smooth and conform to a straight line before the blocks are laid. Bituminous expansion joint filler, conforming to the requirements for "Vitrified Brick Pavement," shall be used in the spaces between the rail filler and the block.

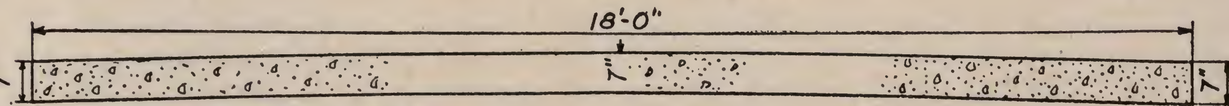
Basis of Payment. Paving around inlets and railway track block liners will be paid for at the contract unit price per square yard for "Vitrified Brick Pavement," or "Wood Block Pavement," or "Stone Block Pavement," as the case may be, complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto.

The "Railway Rail Channel Filler" specified above will not be paid for directly, but will be included in the contract price per square yard for the completed pavement.

Concrete Pavements

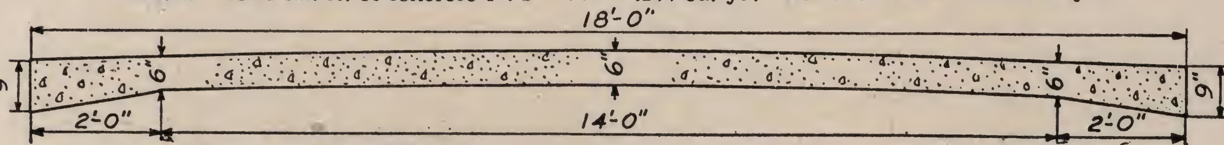
MATERIALS REQUIRED PER LINEAL FOOT, PER MILE AND PER CUBIC YARD FOR VARIOUS MIXES AND SECTIONS

Compiled by the Portland Cement Association



Area cross section = 10.5 sq. ft.

Cu. yd. of concrete per lin. ft. = .389	Cu. yd. per mile = 2053.92 cu. yd.
Cement for 1 lin. ft. of concrete 1 : 1½ : 3 = .743 bbl.	For one mile = 3907.2 bbl.
Sand for 1 lin. ft. of concrete 1 : 1½ : 3 = .163 cu. yd.	For one mile = 862.6 cu. yd.
Stone for 1 lin. ft. of concrete 1 : 1½ : 3 = .331 cu. yd.	For one mile = 1747.7 cu. yd.
Cement for 1 lin. ft. of concrete 1 : 2 : 3 = .677 bbl.	For one mile = 3574.6 bbl.
Sand for 1 lin. ft. of concrete 1 : 2 : 3 = .202 cu. yd.	For one mile = 1066.6 cu. yd.
Stone for 1 lin. ft. of concrete 1 : 2 : 3 = .299 cu. yd.	For one mile = 1578.7 cu. yd.



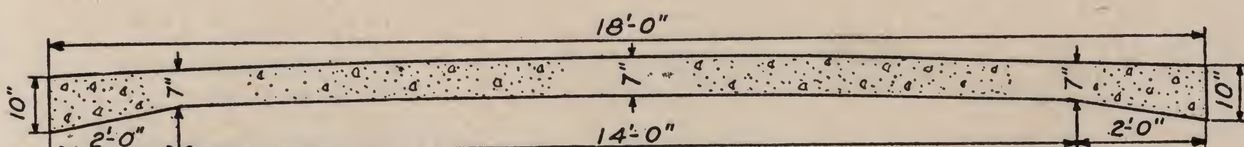
Area of cross section = 9.5 sq. ft.

Cu. yd. of concrete per lin. ft. = .352	Cu. yd. per mile = 1858.6 cu. yd.
Cement for 1 lin. ft. of concrete 1 : 1½ : 3 = .672 bbl.	For one mile = 3548.2 bbl.
Sand for 1 lin. ft. of concrete 1 : 1½ : 3 = .148 cu. yd.	For one mile = 781.4 cu. yd.
Stone for 1 lin. ft. of concrete 1 : 1½ : 3 = .299 cu. yd.	For one mile = 1578.7 cu. yd.
Cement for 1 lin. ft. of concrete 1 : 2 : 3 = .612 bbl.	For one mile = 3231.4 bbl.
Sand for 1 lin. ft. of concrete 1 : 2 : 3 = .183 cu. yd.	For one mile = 966.2 cu. yd.
Stone for 1 lin. ft. of concrete 1 : 2 : 3 = .271 cu. yd.	For one mile = 1430.9 cu. yd.

Cement for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 1.91 bbl.; 1 : 2 : 3 Mix. = 1.74 bbl.

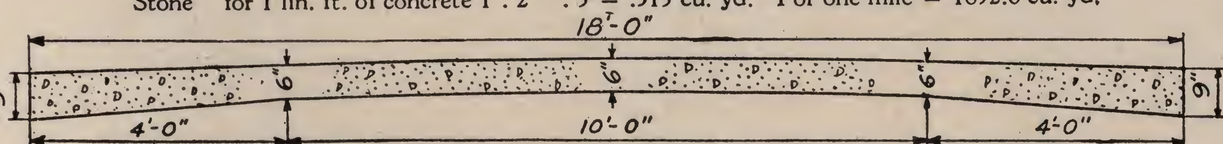
Sand for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 0.42 cu. yd.; 1 : 2 : 3 Mix. = 0.52 cu. yd.

Stone for 1 cu. yd. of concrete { 1:1½:3 Mix. = 0.85 cu. yd.; 1:2 :3 Mix. = 0.77 cu. yd.



Area of cross section = 11 sq. ft.

Cu. yd. concrete per lin. ft. = .407	Cu. yd. per mile = 2149.0 cu. yd.
Cement for 1 lin. ft. of concrete 1 : 1½ : 3 = .777 bbl.	For one mile = 4101.6 bbl.
Sand for 1 lin. ft. of concrete 1 : 1½ : 3 = .171 cu. yd.	For one mile = 902.9 cu. yd.
Stone for 1 lin. ft. of concrete 1 : 1½ : 3 = .346 cu. yd.	For one mile = 1826.9 cu. yd.
Cement for 1 lin. ft. of concrete 1 : 2 : 3 = .708 bbl.	For one mile = 3738.2 bbl.
Sand for 1 lin. ft. of concrete 1 : 2 : 3 = .212 cu. yd.	For one mile = 1119.4 cu. yd.
Stone for 1 lin. ft. of concrete 1 : 2 : 3 = .313 cu. yd.	For one mile = 1652.6 cu. yd.



Area of cross section = 10 sq. ft.

Cu. yd. of concrete per lin. ft. = .370	Cu. yd. per mile = 1953.6 cu. yd.
Cement for 1 lin. ft. of concrete 1 : 1½ : 3 = .707 bbl.	For one mile = 3733.0 bbl.
Sand for 1 lin. ft. of concrete 1 : 1½ : 3 = .155 cu. yd.	For one mile = 818.4 cu. yd.
Stone for 1 lin. ft. of concrete 1 : 1½ : 3 = .315 cu. yd.	For one mile = 1663.2 cu. yd.
Cement for 1 lin. ft. of concrete 1 : 2 : 3 = .644 bbl.	For one mile = 3400.3 bbl.
Sand for 1 lin. ft. of concrete 1 : 2 : 3 = .192 cu. yd.	For one mile = 1013.8 cu. yd.
Stone for 1 lin. ft. of concrete 1 : 2 : 3 = .285 cu. yd.	For one mile = 1504.8 cu. yd.

Cement for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 1.91 bbl.; 1 : 2 : 3 Mix. = 1.74 bbl.

Sand for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 0.42 cu. yd.; 1 : 2 : 3 Mix. = 0.52 cu. yd.

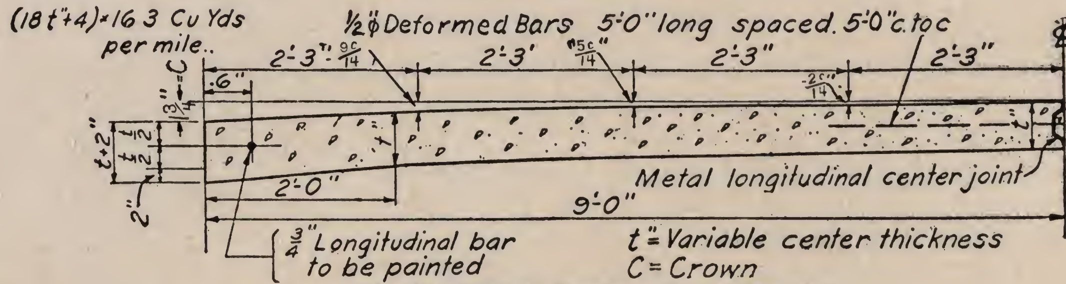
Stone for 1 cu. yd. of concrete { 1:1½:3 Mix. = 0.85 cu. yd.; 1:2 :3 Mix. = 0.77 cu. yd.

Based on 1 bbl. cement equal 4 cu. ft.; voids in stone, 45 per cent.
Factors used from Taylor and Thompson: "Concrete, Plain and Reinforced."

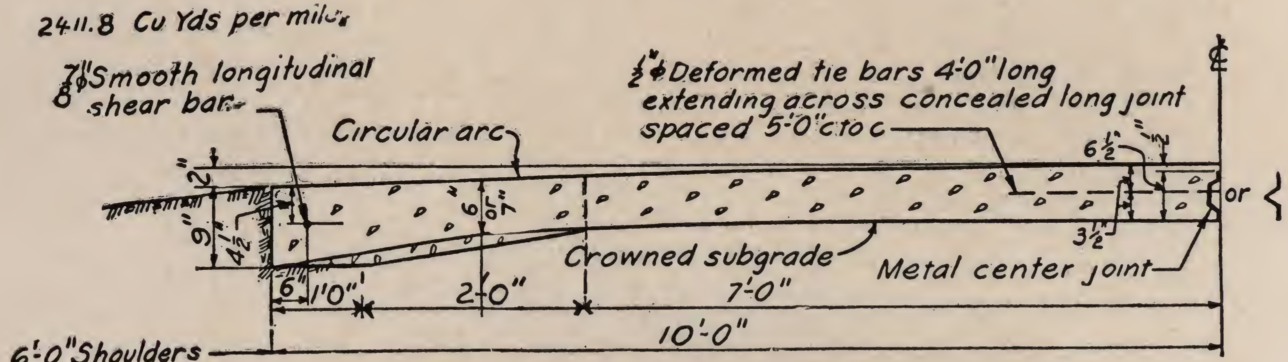
Concrete Pavements

TYPICAL CROSS-SECTIONS OF VARIOUS STATES

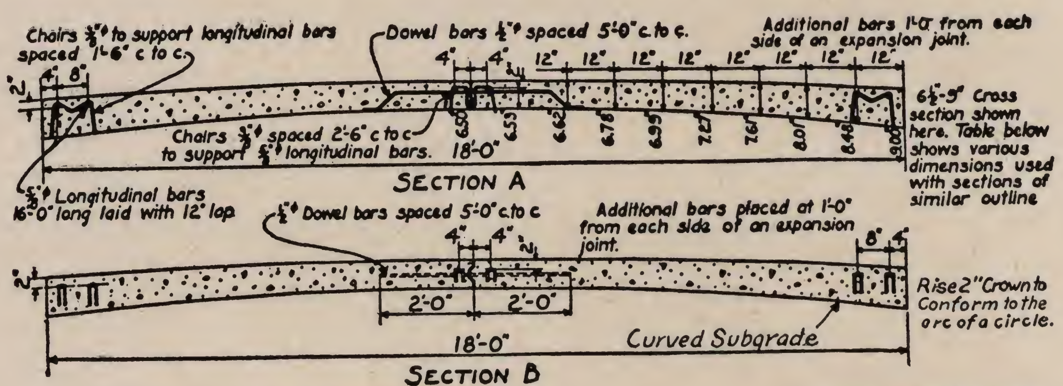
Courtesy Portland Cement Association

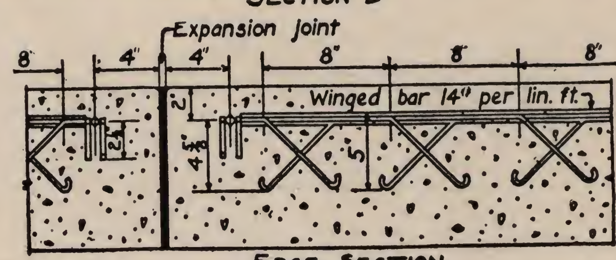


Ohio State Highway Department Concrete Pavement



Illinois State Highway Department Concrete Pavement





EDGE SECTION
(Detail of section B)

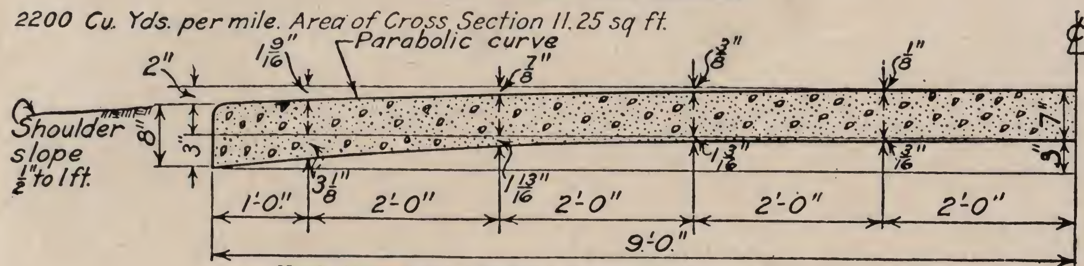
		Cu. Yds. Conc. per Mile	Area of Cross Section
18' Roadway	6½"x 9"	2152.44 cu. yds.	11.01 sq. ft.
	6 x 8½"	2005.77 " "	10.25 " "
	6" x 8"	1956.10 " "	10.00 " "
	5½"x 7½"	1809.44 " "	9.26 " "
16' Roadway	6" x 8"	1739.35 " "	8.90 " "
	5½"x 7½"	1608.57 " "	8.23 " "
	5" x 7"	1478.5 " "	7.56 " "

Pennsylvania State Highway Department Concrete Pavement

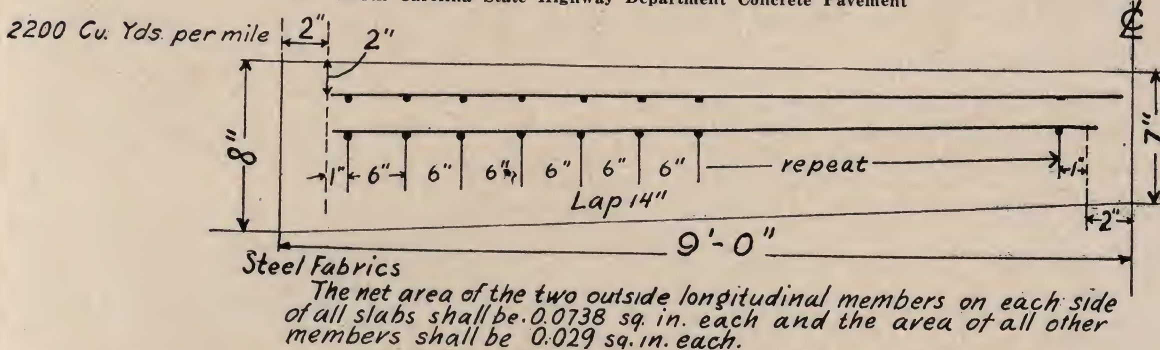
Concrete Pavements

TYPICAL CROSS-SECTIONS OF VARIOUS STATES

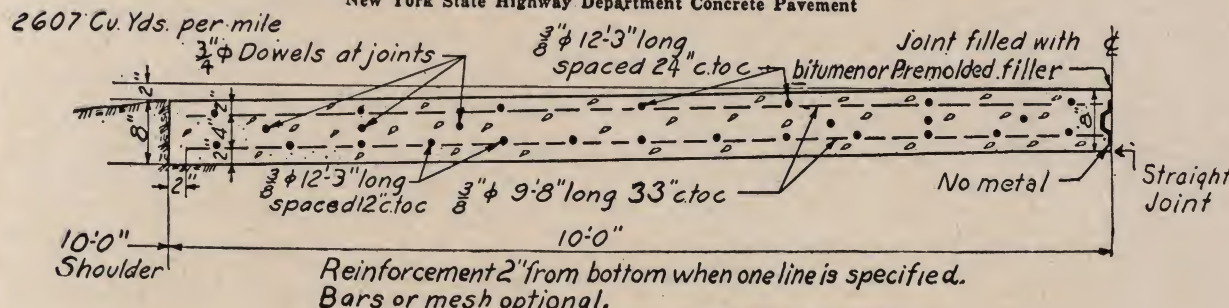
Courtesy Portland Cement Association



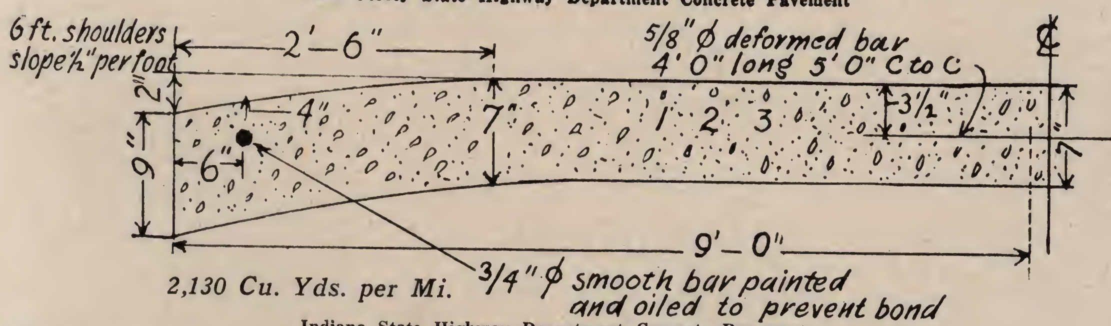
North Carolina State Highway Department Concrete Pavement



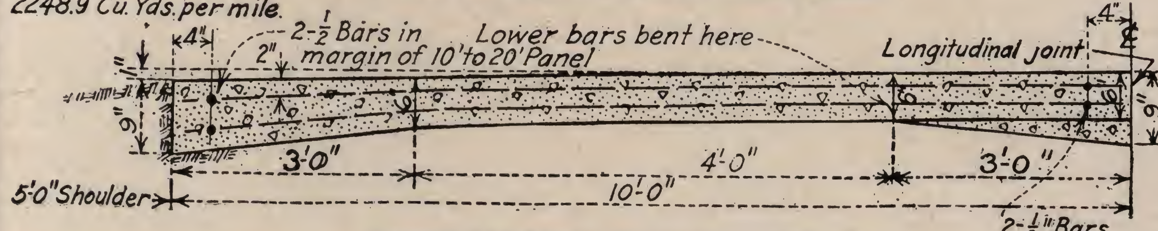
New York State Highway Department Concrete Pavement



New Jersey State Highway Department Concrete Pavement



Indiana State Highway Department Concrete Pavement



California State Highway Department Concrete Pavement

One-Course Portland Cement Concrete Pavement for Highways

From the Copyrighted Proceedings, American Concrete Institute, Volume 21, 1925

These Specifications were approved at the convention of the American Concrete Institute Feb. 26, 1925, for submission to letter ballot of the membership. They were accepted on the letter ballot and now are the Institute's standard specifications.

I. GENERAL

1. It is the intent of these specifications to cover the requirements for the materials and construction of Portland Cement Concrete Highway Pavement wherein the concrete is of uniform proportions from top to bottom of slab.

II. MATERIALS

(A) Cement

2. Cement shall be a standard portland cement which at the time it is incorporated in the pavement mixture, shall conform to the Standard Specifications and Tests for Portland Cement (Serial Designation: C9-21) of the American Society for Testing Materials, and subsequent revisions thereof.

(B) Aggregates

3. Prior to placing any orders for aggregates the contractor shall advise the engineer of the proposed source or sources of supply of aggregates. The engineer may require the contractor to submit 50-lb. samples of all aggregates proposed for use. If the engineer finds such samples fulfill the requirements of these specifications for aggregates, similar material shall be considered as acceptable. Acceptance of samples shall not be construed as a guarantee of acceptance of all materials from the same source, and it shall be understood that any aggregates which do not meet with the requirements of these specifications will be rejected. Upon receiving notification of the proposed source or sources of aggregate supply, the engineer may elect to investigate and test the aggregate supply at the source; in which case he shall notify the contractor as to acceptability, or non-acceptability of the proposed aggregates. The engineer shall notify the contractor, after agreement upon a source or sources of aggregate supply, whether routine tests of aggregates during construction will be made at the source of supply or at the point of receipt.

4. (a) Fine Aggregate.—Fine aggregate shall consist of natural sand, stone screenings, slag sand, tailings, chatts, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated grains. When incorporated in the pavement mixture, fine aggregate shall be free from frost, frozen lumps, injurious amounts of dust, mica, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances. Ninety-five per cent of the fine aggregate, when dry, shall pass a one-fourth (¼) in. sieve; not more than 25 per cent shall pass a 50-mesh sieve, and not more than 5 per cent by weight shall pass a 100-mesh sieve. In no case shall fine aggregate be accepted containing more than 3 per cent, by dry weight, nor more than 5 per cent by dry volume, nor more than 7 per cent by wet volume, of clay, loam, or silt. If any sample of fine aggregate shows more than 7 per cent of clay, loam or silt, in one hour's settlement after shaking in an excess of water, the material represented by the sample will be rejected. Fine aggregate shall be of such a quality that mortar composed of portland cement and the fine aggregate when made into 2x4 in. cylinders, in the same proportions as will be used in the concrete mixture for the pavement, shall show compressive strength at 7 and 28 days equal to or greater than the compressive strength of cylinders composed of mortar of the same proportions of portland cement and standard Ottawa sand. For proportioning test cylinders, portland cement and fine aggregate and standard Ottawa sand shall be measured by weight, and the same portland cement shall be used with the Ottawa sand as with the fine aggregate to be tested.

5. (b) Coarse Aggregate.—Coarse aggregate shall consist of one of the following materials, or a combination thereof: crushed rock, pebbles (gravel), air cooled blast furnace slag, chatts or tailings. The particles of coarse aggregate shall be of clean, hard, tough, durable material, free from vegetable or other deleterious substances, and shall contain no soft, flat, or elongated pieces. Coarse aggregate, except air cooled blast furnace slag, shall show not more than 6 per cent loss in the wear test.

(Note: In many cases, it will be necessary for the engineer to specify the sizes, grading, and quality of coarse aggregate in accordance with local conditions. In every case, the engineer should provide specifications which will require the use of the best coarse aggregate which is economically available. The following specifications covering size and grading of coarse aggregate will be found applicable in most sections of the country, and are intended for use with the 1:2:3½, 1:2:3, or 1:1½:3, mixture.)

6. The size of the coarse aggregate shall be such as to pass a 3-in. round opening. Coarse aggregate shall be uniformly graded within the limits shown in the following table, and any material which does not come within the limits specified shall be rejected.

Passing 3-in. round opening, 100 per cent.

Passing 2-in. round opening, not less than 82 per cent nor more than 95 per cent.

Passing ½-in. round opening, not less than 15 per cent nor more than 25 per cent.

Passing ¼-in. sieve, not more than 5 per cent.

7. Crushed Rock shall consist of particles of rock produced by quarrying and crushing ledge rock, field boulders, or pebbles, from which, after crushing, all dust and pieces below one-quarter (¼) in. size have been screened out. Crushed rock shall conform in quality to the specifications under "Coarse Aggregate".

8. Pebbles (Gravel) shall consist of loose material containing only particles retained upon a ¼-in. sieve, resulting from the natural crushing and erosion of rocks. Pebbles must have wearing qualities at least equal to crushed stone. Pebbles shall conform in quality to the specifications under "Coarse Aggregate".

9. Air Cooled Blast Furnace Slag.—The broken slag shall consist of roughly cubical fragments of air cooled blast furnace slag, reasonably uniform in density and quality and reasonably free from metallic iron, containing no dirt or other objectionable matter. The slag shall weigh not less than seventy (70) pounds per cubic foot.

10. Chatts, or Tailings are terms locally applied to by-products, or waste products, of certain mining and industrial operations. When used as coarse aggregate for concrete pavements, such materials shall substantially conform to the specifications under "Coarse Aggregate".

11. (c) Mixed Aggregate.—Mixed aggregate shall consist of a combination of fine and coarse aggregates. That portion of mixed aggregate passing a one-quarter (¼) in. sieve shall conform to the requirements for fine aggregate; and that portion of mixed aggregate retained on a one-quarter (¼) in. sieve shall conform to the requirements for coarse aggregate.

(C) Water

12. Water shall be clean, free from oil, acid, alkali, or vegetable matter.

(D) REINFORCEMENT

13. Reinforcement shall consist of steel fabric, or of steel bars, or a combination of both and shall have an effective weight exclusive of dowel bars at joints and of circumferential bars of at least .... pounds per 100 square feet.

14. (a) Steel Fabric.—Steel fabric shall be manufactured from cold drawn wire and shall comply with tentative standards of the American Society for Testing Materials, Serial Designation A82-21T.

15. The spacing of primary members shall be not more than .... inches, and of secondary members not more than .... inches.

16. (b) Steel Bar Reinforcement.—This style of reinforcement shall consist of steel bars of the size, shape and spacing shown on the plans, and shall be properly formed into mats. All intersections of longitudinal and transverse bars along the exterior edges of the mat and every other intersection of the longitudinal and transverse bars in the interior of the mat shall be securely wired or clipped together to resist displacement during handling and concreting operations. The materials shall have an effective weight of not less than .... lb. per 100 sq. ft., exclusive of laps, ties, clamps, chairs, and such portions of the bars as are not in the plane of the mat for their full lengths.

17. Steel bars shall comply with the standard requirements for concrete reinforcement bars, structural and intermediate grades, of the American Society for Testing Materials, Serial Designation A15-14. All bar reinforcement when placed in the pavement shall be free from excess rust, scale, or other substance which prevents the bonding of the concrete to the reinforcement. When in storage on the work, bars shall be protected from corrosion by placing them on a dry platform under a weather-proof cover.

(E) Joint Filler

18. Joint filler shall consist of prepared strips of fibre matrix and bitumen, containing not more than 25 per cent of inert material, having thickness of .... in., and width equal to .... in. greater than the thickness of the pavement at any point. The bitumen used in manufacture of the joint filler may be either tar or asphalt of a grade that will not become soft enough to flow in hot weather, nor brittle in cold weather. The prepared strips shall be cut to conform to the cross-section of the pavement and in lengths equal to the width of the pavement, except that strips equal in length to half the width of the pavement may be used when laced or clipped together at the center in a workmanlike and effective manner.

(F) Shoulders

19. (Any special materials for the construction of shoulders should be here described as desired by the engineer.)

III. SUBGRADE

20. Subgrade will be considered as that portion of the highway upon which the pavement is to be placed.

(A) Fine Grading

21. Fine grading will include the finished excavation and embankment which may be necessary to bring the subgrade to the required elevation, alignment, and cross-section. All suitable materials removed from the excavation in fine grading shall be used as far as practicable in the formation of the embankment, as may be required. Such material not used in embankment may be deposited on the shoulders as directed by the engineer. When the amount of the embankment exceeds the amount of the material available from excavation, suitable material shall be obtained by the contractor from borrow pits located beyond the limits of the shoulders or embankment slopes. Such borrow pits shall be left in neat condition, such as will drain completely. Ditch sections and back slopes of cuts must conform to the plans, and be left with neat and uniform appearance.

(B) Preparation and Maintenance

22. The subgrade shall be constructed to have, as nearly as practicable, a uniform density throughout its entire width. Wherever the subgrade extends beyond the lateral limits of an old roadway or wherever an old gravel, macadam, or other hard compacted crust comes within 6 in. of the elevation of the finished subgrade, such old roadway or crust shall be ploughed, loosened or scarified to a depth of at least 6 in. and the loosened material redistributed across the full width of the subgrade, adding suitable material, when necessary, so that when compacted to the required elevation, alignment, and cross-section, the subgrade will approach as nearly as possible, a condition of uniform density. Compression of the subgrade material shall be accomplished with a self-propelled roller weighing not less than 3 tons. Hand-tamping portions of the subgrade may be directed by the engineer when necessary. There shall not be left on the subgrade or shoulders, berms or ridges of earth or other material that will interfere with the immediate discharge of water from the subgrade to the side ditches, and the subgrade shall be maintained free from ruts so that it will, at all times, drain properly.

23. All depressions developing under traffic on the subgrade, or in connection with rolling shall be filled with suitable material. Rolling shall be continued until the subgrade is uniformly compacted, properly shaped, and true to grade and alignment. It is not intended that the rolling shall be continued beyond this point, as the purpose of rolling is not to produce a subgrade that cannot be further compacted, but to produce a uniformly compacted subgrade. All hauling shall be distributed over the width of the subgrade so far as practicable, so as to leave it in a uniformly compacted condition.

24. After being prepared in the above manner, the subgrade shall be so maintained until the concrete pavement has been placed thereon.

(C) Checking and Acceptance

25. Immediately prior to placing concrete pavement on the subgrade, it shall be checked by means of an approved scratch template, resting on the side forms, having the scratch points placed not less than 8 in. apart, and to the exact elevation and cross-section for the subgrade surface. The scratch template shall be drawn along the forms so that the plane of the points will be at a right angle to the grade line, and the long axis of the template at a right angle to the center line of the pavement. All high places indicated by the scratch points shall be removed to true grade, and any low places back filled with suitable material and rolled or hand tamped until smooth and firm. The subgrade shall be checked and completed in accordance with these requirements for a distance of not less than 100 ft. in advance of the concrete. If hauling over the subgrade after it has been finished and checked as above specified, results in ruts or other objectionable irregularities, the contractor shall re-roll or hand-tamp the subgrade and place it in smooth and satisfactory condition before the pavement is deposited upon it. If the condition of the subgrade is such that it cannot be placed in satisfactory condition to receive the pavement by the above methods, placing pavement may be stopped by the engineer unless the contractor can provide and haul over suitable trackways or use other satisfactory means for the protection and maintenance of the subgrade.

(D) Special Treatment

26. (Special treatment may be specified for certain subgrades such as sand, gumbo, adobe, and other materials, which cannot be satisfactorily prepared for pavement by the methods specified in the foregoing paragraphs.)

IV. FORMS

(A) Materials

27. Wooden forms shall be dressed to 3-in. thickness, and equal in depth to the thickness of the pavement at the sides. Forms shall rest upon stakes driven into the ground within 1 ft. of each end of each separate piece, and at intervals not greater than 5 ft. elsewhere. Forms shall be held by stakes driven into the ground along the outside edge at intervals of not more than 6 ft., two stakes being placed at each joint. The forms shall be firmly nailed to the side stakes, and firmly braced at any point where necessary to resist the pressure of the concrete or the impact of the tamper. Forms shall be capped along the inside upper edge with 2-in. angle irons.

28. Metal forms shall be of shaped steel sections not less than 10 ft. in length, for tangents and for curves having radii of 150 ft. and over. For curves of less radii, sections 5 ft. long may be used. Forms must have a depth equal to the side thickness of the pavement. Forms shall be made of steel plate of approved section. At least three bracing pins or stakes shall be used to each 10 ft. of form, and the bracing and support must be ample to resist the pressure of the concrete and the impact of the tamper without springing.

(B) Setting

29. Forms shall be set to exact grade and alignment at least 500 ft. in advance of the point of depositing concrete. Before setting the sections must be thoroughly cleaned. After setting they shall be thoroughly oiled before concrete is placed against them. Forms in place will be subject to check and correction of line or grade at any time.

V. PAVEMENT SECTION

30. Width, Thickness and Crown of concrete pavement shall be as shown on the plans for the improvement.

VI. JOINTS

31. The joints to be formed shall be transverse or longitudinal. They shall be tested during and after finishing with a 10 ft. straight edge and any irregularities in the surface shall be immediately corrected. Expansion joints shall be formed between the pavement under construction and all other rigid types of pavement or structure to which it may be adjacent. All joints shall be edged to a radius of 1/8 in. Joints shall be made as follows:

(A) Transverse Expansion Joints

32. Transverse expansion joints shall be .... in. wide, spaced .... ft. apart. A bulkhead cut to the exact cross-section of the pavement, shall be securely staked in place at right angles to the center line and surface of the pavement. The premolded joint filler shall be placed against the bulkhead and held in position by pins on which there is an outstanding lug. Concrete shall be deposited on both sides of the bulkhead before it is removed. After the concrete has been struck off the bulkhead shall be removed by lifting it slowly from one end and replacing it with concrete as it is lifted, so that the joint-filler will be left in the correct position.

33. When expansion joints are made at the end of the day's work they shall be formed by finishing the concrete to the bulkhead, placed as before specified. When work is resumed the joint-filler shall be placed against the hardened concrete and held in position by pins until fresh concrete is placed against it.

34. In pavements with integral curb the joint shall be continuous in a straight line through pavement and curb.

35. Joints shall be opened on the edges for their entire depth, upon removal of the forms.

36. Before the pavement is opened to traffic the jointfiller shall be trimmed off to a uniform height of 1/4 in. above the surface of the pavement.

(B) Longitudinal Expansion Joints

37. Longitudinal expansion joints shall be formed by placing the filler against the form, bulkhead, curb, or adjacent structure and placing the concrete against it. The filler shall extend the full depth of the pavement, and be flush with the pavement surface.

(C) Transverse Construction Joints

38. Transverse construction joints shall be formed whenever it is necessary to stop concreting for 30 min. or longer, except at expansion joints, by staking in place a bulkhead, as specified for transverse expansion joints, and finishing the concrete to the bulkhead. An edging tool shall be used along the bulkhead to make the construction joint a regular and well-defined line. When the plans require steel dowels across transverse joints in this bulkhead there shall be holes spaced 3 ft., center to center, 3 in. below the surface of the finished pavement, through which 3/4-in. plain round steel rods 4 ft. long shall be inserted with 2 ft. projecting. At least one-half length of each bar shall be encased in heavy paper or coated with paint or oil in such a manner as to prevent a bond between the steel and the concrete.

39. When work is resumed the plank shall be removed, care being taken not to disturb the rods or the concrete. The fresh concrete shall be placed directly against the face of the concrete previously laid and carefully worked around the rods.

40. If concreting must be stopped within 10 ft. of a previously made transverse joint the concrete shall be removed to this joint.

(D) Longitudinal Construction Joints

41. Longitudinal construction joints shall be formed where required and must be straight and vertical. When so indicated on

the plans, steel dowels shall be used as provided in the preceding section.

VII. WATER SUPPLY

(A) Equipment

42. Where necessary for the supply of water for all operations described in these specifications, duplicate pumps, connected to an adequate pipe line along the improvement, shall be provided by the contractor. The pipe line must be fitted with drains at the low points, and air relief valves at the high points, and with convenient outlets for all paving operations. Where the concrete mixer operates on the subgrade, the pipe line shall have a minimum diameter of 2 in. For supplying a mixer using more than 4 sacks of cement per batch, 60 per cent of the pipe line shall have a minimum diameter of 3 in., and the remaining 40 per cent shall have a minimum diameter of 2 in. The large diameter pipe shall lead from the pump.

(B) Priority to Water Supply

43. The concrete pavement in place, for 10 days after laying, and the subgrade preparation, shall have prior rights to the water supply. If it should develop there is not sufficient water for all purposes, the concrete mixer shall be shut down until the water needs of the curing and subgrading operations have been cared for.

VIII. PROPORTIONING AND MIXING CONCRETE

(A) Proportioning

44. (a) Measuring Materials.—The method of measuring materials for the concrete, including water, shall be such as to insure the required proportions of each of the materials as directed by these specifications. One sack of portland cement (94 lbs. net) shall be considered 1 cu. ft.

45. (b) Proportions.—The concrete shall be proportioned 1 sack of portland cement, not more than .... cu. ft. of fine aggregate, and not more than .... cu. ft. of coarse aggregate. A cu. yd. of concrete in place, measured between neat lines, must contain .... barrels of portland cement. The engineer shall compare the calculated amount of cement required by these specifications with the amounts actually used in each section of concrete .... ft. long, or between successive transverse joints. If the amount of cement actually used in the pavement varies from the specified amount by more than 3 per cent for any section, the engineer may require the proportions of the concrete to be adjusted so as to use the specified amount of cement. If it is found that the amount of cement used in any section is 92½ per cent or less, of the specified quantity, the contractor shall be required to remove such section or sections, and replace them with concrete made in accordance with these specifications. Such removal and replacement shall be done at the expense of the contractor.

(B) Mixing

46. (a) Operation of Mixer.—The concrete shall be mixed in a batch mixer, with the "boom and bucket" type of delivery. The capacity of the drum shall be such that only whole bags of cement are used in each batch. Mixing shall continue for at least 1 min. after all materials, including water, are placed in the drum, and before any part of the batch is discharged. The drum shall be revolved not less than 14 nor more than 18 revolutions per minute. The drum shall be completely emptied before receiving materials for the succeeding batch. The volume of the mixed material in each batch shall not exceed the mixer manufacturer's rated capacity of the drum.

47. The mixer shall be provided with a water measuring tank into which mixing water shall be discharged, having a visible gauge so that the amount of water for each batch may be separately and accurately measured. The mixer shall be provided with an approved batch timing device which will automatically lock the batch discharging device during the full mixing time and release it at the end of the mixing period. The timer device shall have a bell which will automatically ring at the end of the mixing period. This device shall be subject to inspection and adjustment by the engineer at any time.

48. (b) Retempering.—Mortar or concrete which has partially set shall not be retempered by being mixed with additional materials or water.

49. (c) Central Mixing Plants.—The use of central mixing plants and the transportation of mixed concrete is permitted under these specifications, provided there is no segregation of the mixed concrete when it is delivered at the point where it is to be deposited in the pavement. The period between mixing and placing in the pavement shall not exceed 40 min., and this period may be reduced at the direction of the engineer. The concrete must be of workable consistency when placed on the subgrade.

50. (d) Consistency.—The concrete mixture shall contain no more water than is necessary to produce a workable mass which can be brought to a satisfactory finish in the pavement. The amount of water used shall not exceed 6¼ gal. per sack of cement, when the aggregates are dry.

IX. PLACING CONCRETE AND REINFORCEMENT

(A) Inspection of Subgrade

51. (a) Rechecking Subgrade.—Immediately before placing concrete, or any type of reinforcement, the subgrade shall be rechecked by means of a scratch template as provided in paragraph 25 of these specifications, and any inequalities corrected as therein provided.

52. (b) Condition of Subgrade.—Concrete shall be placed only on a moist subgrade, but there shall be no pools of standing water. If the subgrade is dry, it shall be sprinkled with as much water as it will absorb readily. The engineer may direct that the subgrade be sprinkled or thoroughly wet down from 12 to 36 hours in advance of placing concrete, where such procedure may be deemed necessary.

(B) Placing Reinforcement

53. Steel fabric reinforcement of the size and weight shown on the plans, shall be placed 2 in. below and parallel to the finished surface of the pavement unless otherwise indicated. Fabric shall extend to within 2 in. of sides and ends of slabs. All laps of fabric sections shall be not less than three-fourths of the spacing of members in the direction lapped. Steel bar reinforcement shall be placed 3 in. below the finished surface of the pavement unless otherwise indicated on the plans. Transverse bars shall extend to within 2 in. of the margins of the pavement. Bar reinforcement shall be placed and securely supported in correct position before any concrete is laid. All intersections of longitudinal and transverse bars shall be securely wired or clipped together to resist displacement during concreting operations.

(C) Placing Concrete

54. The mixed concrete shall be deposited rapidly on the subgrade to the required depth and for the entire width of the pavement section, in successive batches and in a continuous operation without the use of intermediate forms or bulkheads between joints. While being placed, the concrete shall be vigorously sliced and spaded with suitable tools to prevent formation of voids or honeycomb pockets. The concrete shall be especially well spaded and tamped against the forms. When the concrete is placed in two horizontal layers to permit use of steel reinforcement, the first layer shall be roughly struck off with a template or screed, riding on the side forms, at the correct elevation to permit placing the reinforcement in specified position. The concrete above the reinforcement shall be placed within 15 min. after the first layer has been placed. Any dust, dirt or foreign matter which collects on the first layer shall be carefully removed before the upper layer is placed.

55. Whenever the placing of concrete is to be suspended for more than 30 min., a transverse joint shall be formed, at the point directed by the engineer, to close the section. Any concrete in excess of that needed to complete a section, when work is stopped for more than 30 min., shall not be used in the pavement.

(D) Finishing

56. (a) General.—Experienced and skillful workmen must be employed at all times for preparing the surface of the pavement. The concrete shall be brought to the specified contour by means of a heavy screed or template, fitted with handles, weighing not less than 15 lb. per lin. ft. This screed or template may be of steel, or of wood shod with steel. It shall be shaped to the cross-section of the pavement, and have sufficient strength to retain its shape under all working conditions. The template or screed shall rest on the side forms and shall be drawn ahead with a sawing motion. At transverse joints, the template shall be drawn not closer than 3 ft. toward the joint, and shall then be lifted and set down at the joint and drawn backwards away therefrom. Surplus concrete shall then be taken up with shovels and thrown ahead of the joint.

57. (b) Belting.—The concrete shall be finished by using a belt of wood, canvas, or rubber, not less than 6 nor more than 12 in. wide, and at least 2 ft. longer than the width of the pavement. The belt shall be applied with a combined crosswise and longitudinal motion. For the first application vigorous strokes at least 12 in. long shall be used, and the longitudinal movement along the pavement shall be very slight. The second application of the belt shall be immediately after the water sheen disappears, and the stroke of the belt shall be not more than 4 in. and the longitudinal movement shall be greater than for the first belting.

58. (c) Machine Finishing.—When a finishing machine is used it shall be so designed and operated as to strike off and consolidate the concrete, eliminating ridges and producing a true and even surface. The operation of the machine shall be so controlled as to keep the coarse aggregate near the finished surface of the pavement. Repeated operation of the machine over a given area is to be avoided.

59. A hand tamping template and belt must be kept for use in case the tamping machine breaks down.

60. (d) Longitudinal Floating.—Immediately after the screeding specified under IX (D) 56 (a) has been completed, the surface should be inspected for high or low spots and any needed corrections made by adding or removing concrete. Rough spots should be gone over with a long handled float and worked to proper contour and grade. The entire surface shall then be floated longitudinally, with a float board not less than 16 ft. long and 8 in. wide. This float board shall have convenient plow-handles at each end. It shall be operated by two men, one at each end, each man standing on a bridge spanning the pavement. The lower surface of the float board shall be placed upon the surface of the concrete with the long dimension parallel to the center line of the pavement. The float shall then be drawn back and forth in slow strokes about

2 ft. long, and advancing slowly from one side of the pavement to the other. The purpose of this operation is to produce a uniform even surface on the concrete, free from transverse waves. The two bridges on which the workmen stand should be placed about 18 ft. apart when the length of the float is 16 ft. When the entire width of the pavement has been floated in this manner from one position of the bridges, they shall be moved ahead about 12 ft. so that the next section to be floated shall overlap the one previously so floated from 3 to 4 ft. After this floating has been completed, and all transverse waves eliminated, the surface shall be finished by the belting process specified in paragraph 57.

61. (e) Finishing at Joints and Tooling.—The contractor shall provide a suitable split float or split roller, having a slot to fit over expansion joints. This device shall be so arranged as to float the surface for a width of at least 3 ft. on each side of the joint simultaneously. This device shall be used in such manner as to produce a true surface across the joint. Edges of the pavement, at joints and side shall be tooled for a width of 2 in., the corners rounded to a radius of ¼-in.

62. (f) Trueness of Surface.—The finished surface of the pavement must conform to the grade, alignment and contour shown on the plans. Just prior to the final finishing operation, the surface shall be tested with a light straight-edge, 10 ft. in length, laid parallel to the center line of the pavement. Any deviation shall be immediately corrected.

63. The contractor shall be held responsible for the trueness of surface of the pavement, and shall be required to make good any deviation from the alignment, grade and contour shown on the plans.

X. CURING AND PROTECTION

(A) Burlap Cover

64. The contractor shall provide a sufficient amount of burlap or canvas for every mixer on the job, to cover all of the pavement laid in any one day's maximum run. Burlap or canvas cover shall be made up in sheets 12 ft. wide, and 4 ft. longer than the width of the pavement. Burlap or canvas cover shall be placed on the concrete immediately after the final belting, and shall then be sprayed with water in such a manner that the surface of the pavement will not be damaged. Burlap or canvas cover shall be kept continuously moist by spraying until the concrete has taken final set.

(B) Wet Earth Cover

65. As soon as it can be done without damaging the concrete, the surface of the pavement shall be covered with not less than 2 in. of earth, or 6 in. of hay or straw. This cover shall be kept continuously wet by spraying for 10 days after the concrete is laid.

(C) Sprinkling or Ponding

66. The sprinkling system of curing may be used if approved by the engineer. The sprinkling equipment shall be placed carefully and without injuring the concrete surface. The sprinkling system shall be so arranged, and supplied with sufficient water at ample pressure, to keep every portion of the pavement surface continuously wet (both night and day) for 10 days after laying the concrete. Dikes shall be constructed along both edges of the pavement, with cross-dikes where necessary, and the water flowing off the surface of the pavement shall be collected and led to the ditches or culverts as directed by the engineer. The contractor shall be held responsible for any damage to the roadway, shoulders, or adjacent property, by reason of escaping water.

67. The ponding system of curing may be used at the option of the contractor. Dikes shall be built along both edges of the pavement, with cross-dikes at sufficiently frequent intervals, and the pavement flooded with sufficient water within the dikes to keep all portions of the pavement surface continuously covered with water for 10 days after the concrete is laid.

(D) Cleaning

68. After 14 days, the earth or other cover may be removed. After 30 days, the contractor may use a mormon or a fresno scraper to remove the cover, except that scrapers shall not be used within 1 ft. of expansion joints. Cover within 1 ft. of expansion joints must be removed by hand. Road machines, or blade graders of the 2 or 4-wheel type shall not be used for removing the cover.

69. After the cover has been removed, or ponds emptied and dikes removed, the entire surface of the pavement shall be swept clean and free from dirt and debris. Horse or motor drawn sweepers shall not be operated on the pavement till 30 days have elapsed after the concrete is placed.

(E) Cold Weather Protection

70. Concrete shall not be mixed nor deposited when the temperature is below freezing, except under such conditions as the engineer may direct in writing. If, at any time during the progress of the work, the temperature is, or in the opinion of the engineer, will, within 24 hours, drop to 38 deg. F. the water and aggregates shall be heated, and precautions taken to protect the concrete from freezing until it is at least 10 days old. In no case shall concrete be deposited upon a frozen subgrade, nor shall frozen materials be used in the concrete.

XI. PROHIBITION OF TRAFFIC

(A) Barricades

71. The contractor shall provide and maintain substantial barricades across the pavement, with suitable warning signs by day and by night, to prevent traffic of any kind upon the pavement before it is 21 days old, or before the cover has been removed. The contractor shall provide and maintain watchmen at each mixer, whenever the paving crew is not at work, who shall prevent destruction or removal of barricades, and keep traffic off the pavement.

72. No section of pavement shall be opened to traffic until written instructions have been given by the engineer.

(B) Crossings

73. At public highway and private crossings, the contractor shall provide suitable structures to carry the traffic across the pavement without injury to the concrete. All such structures shall be subject to the approval of the engineer, and he may direct their improvement, or repair, as conditions may require.

XII. CONDITION BEFORE ACCEPTANCE

74. Before the road will be considered completed in accordance with these specifications, and acceptable to the engineer, the pavement, shoulders, ditches, back slopes, and structures, shall be placed in a neat and orderly condition, conforming to the plans and specifications in all respects. Equipment, surplus materials, and construction debris of every description shall be removed from the right of way.

AMERICAN STEEL & WIRE COMPANY

Wire Reinforcing Fabrics for Concrete Pavements

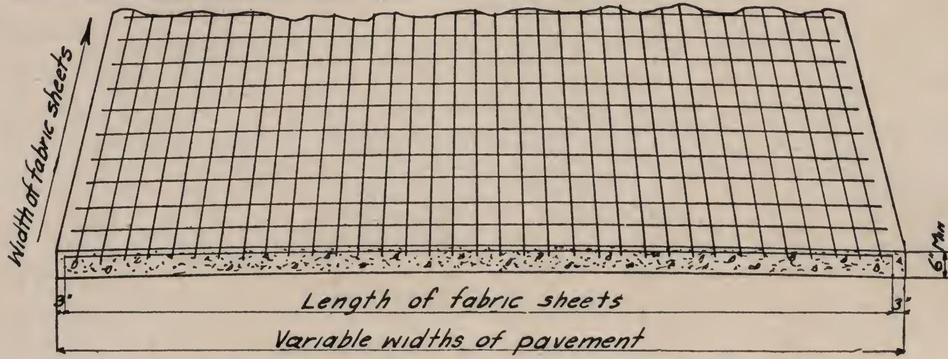
SALES OFFICES

Chicago, 208 So. La Salle St.
Cleveland, Rockefeller Bldg.
Detroit, Foot of First St.
Cincinnati, Union Trust Bldg.
Minneapolis-St. Paul, Merchants National Bank Bldg.
St. Louis, 506 Olive St.
Kansas City, 417 Grand Ave.
Oklahoma City, First National Bank Bldg.
Birmingham, Brown-Marx Bldg.
Memphis, Union and Planters Bk. Bldg.

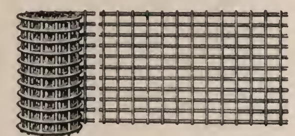
New York, 30 Church St.
Boston, Statler Bldg.
Pittsburgh, Frick Bldg.
Philadelphia, Widener Bldg.
Atlanta, 101 Marietta St.
Worcester, 94 Grove St.
Baltimore, 32 So. Charles St.
Buffalo, 670 Ellicott St.
Wilkes-Barre, Miners Bank Bldg.

Dallas, Praetorian Bldg.
Denver, First National Bank Bldg.
Salt Lake City, Walker Bank Bldg.
United States Steel Products Company
San Francisco, Russ Bldg.
Los Angeles, 2087 E. Slauson Ave.
Portland, 777 Nicolai St.
Seattle, 4th Ave. S. and Conn. St.

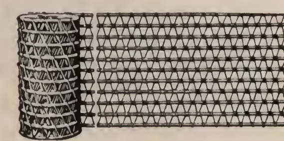
Products: TRIANGLE MESH AND ELECTRIC WELD WIRE FABRICS.



Plan of Typical City Street Pavement Without Center Joint

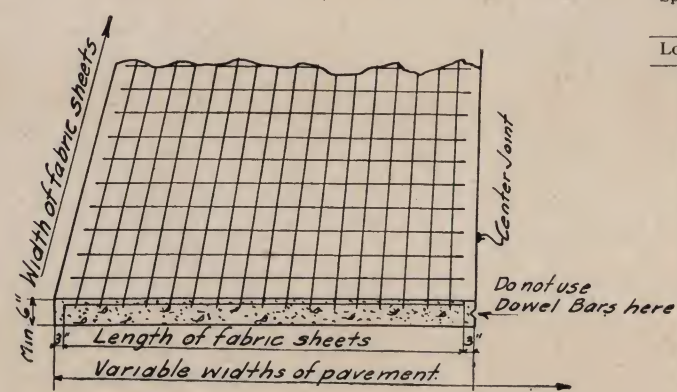


In Rolls or Sheets
Electric Weld



In Rolls or Sheets
Triangle Mesh

Widths of fabric sheets vary with spacing of transverse joints. Maximum width, 10′ 0″. Usual width used is 72″



Half Plan of City Street Pavement with Plain or Grooved Center Joint

Standard Styles American Electrically Welded Fabric for Concrete Roads and Pavements

Spacing of Wires in Inches			American Steel & Wire Company's Steel Wire Gauge No.			Sectional Area Square Inches Per Foot of Fabric		Weight in Pounds per 100 Sq. Ft.
Longit.		Trans.	Longit.		Trans.	Longit.	Trans.	
6	x	6	0	and	0	.148	.148	107
6	x	6	1	and	1	.126	.126	91
6	x	6	2	and	2	.108	.108	78
6	x	6	3	and	3	.093	.093	68
6	x	6	4	and	4	.080	.080	58
6	x	6	5	and	5	.067	.067	49
6	x	6	6	and	6	.058	.058	42
6	x	6	7	and	7	.049	.049	36
6	x	6	8	and	8	.041	.041	30
6	x	12	0	and	0	.148	.074	81
6	v	12	1	and	1	.126	.063	69
6	x	12	2	and	2	.108	.054	59
6	x	12	3	and	3	.093	.047	51
6	x	12	4	and	4	.080	.040	44
6	x	12	5	and	5	.067	.034	37
6	x	12	6	and	6	.058	.029	32
6	x	12	7	and	7	.049	.025	27
6	x	12	0	and	6	.148	.029	65
4	x	12	3	and	7	.140	.025	59
4	x	12	4	and	8	.120	.021	51
4	x	12	6	and	7	.087	.025	40

Lengths of sheets: Standard are 8 feet minimum, car lengths maximum.
Lengths of rolls: Standard 150 feet, 200 feet and 300 feet.
Weights: Above weights based on width of 60 inches measured center to center of selvage longitudinal wires.
Widths: Multiple of the spacing of longitudinal wires up to a maximum of 120 inches.

Recommended Specifications for City Streets

City Streets: The reinforcement shall consist of a steel wire fabric manufactured from cold drawn wire, finished members of which shall develop an ultimate tensile strength of at least 70,000 pounds per square inch and which shall bend cold 180 degrees around a pin the diameter of which is equal to the diameter of the wire specimen without cracking on the outside of the bent portion.

All reinforcement shall be free from excessive rust, scale, paint or coating of any character which will tend to prevent proper bonding of the concrete.

The longitudinal wires of the fabric shall be spaced not less than four (4) nor more than six (6) inches and shall have a sectional area of not less than .... *square inches of steel per foot of fabric. The transverse wires of the fabric shall be spaced not less than four (4) inches nor more than twelve (12) inches and shall have a sectional area of not less than .... *square inches of steel per foot of fabric. The fabric shall weigh not less than .... *pounds per 100 feet of fabric.

**Local conditions govern. For average conditions use 6″x6″—No. 5 and No. 5, weight 49 pounds per 100 square feet or 6″x6″—No. 4 and No. 4, weight 58 pounds per 100 square feet.*

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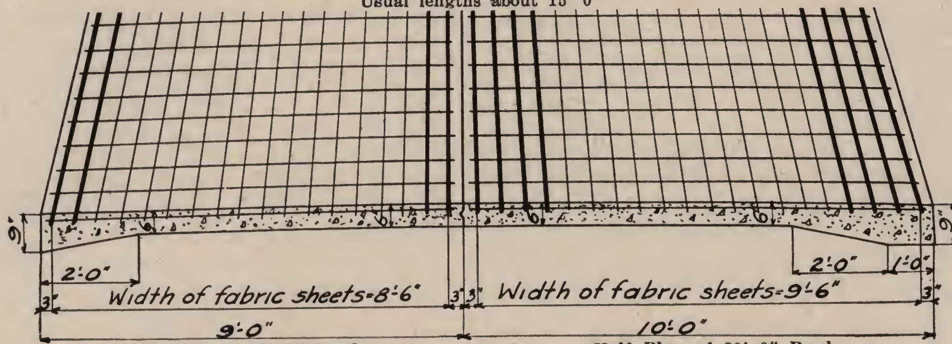
Lengths of fabric sheets vary with spacing of transverse joints and convenience in handling and placing.
Usual lengths about 15′ 0″



Half Plan of 18′ 0″ Road. Half Plan of 20′ 0″ Road

Heavy Edge Road Fabric for 18′ 0″ Road

6″x6″ MESH—ALL WIRES SPACED 6 INCH CENTERS

Number and Gauge of Longitudinal Wires: Heavy Wires Outer Edge	Center Wires	Heavy Wires Inner Edge	Sectional Area of Longitudinals in Square Inches: Total of Heavy Wires Outer Edge	Total of Center Wires	Total of Heavy Wires Inner Edge	Average of All Wires Per Foot Width of Fabric	Gauge and Areas of Cross Wires: Gauge	Sectional Areas Sq. In. Per Foot of Fabric	Total Weight of Fabric Lbs. Per 100 Sq. Ft.	Using 12-Inch Spacing of Cross Wires the Sectional Area of Cross Wires and Total Weights of Fabric Are: Sectional Area Sq. In. Per Foot of Fabric	Total Weight of Fabric Lbs. Per 100 Sq. Ft.
2 @ #0	14 @ #6	2 @ #0	.148	.405	.148	.082	#6	.058	48	.029	38
3 @ #0	12 @ #6	3 @ #0	.221	.347	.221	.093	#6	.058	52	.029	42
4 @ #0	12 @ #6	2 @ #0	.295	.347	.148	.093	#6	.058	52	.029	42
4 @ #0	10 @ #6	4 @ #0	.295	.290	.295	.104	#6	.058	55	.029	45
2 @ #00	14 @ #5	2 @ #00	.172	.471	.172	.096	#5	.067	56	.034	44
3 @ #00	12 @ #5	3 @ #00	.258	.404	.258	.108	#5	.067	60	.034	48
4 @ #00	12 @ #5	2 @ #00	.344	.404	.172	.108	#5	.067	60	.034	48
4 @ #00	10 @ #5	4 @ #00	.344	.337	.344	.121	#5	.067	64	.034	53
2 @ #000	14 @ #4	2 @ #000	.206	.558	.206	.114	#4	.080	66	.040	53
3 @ #000	12 @ #4	3 @ #000	.310	.478	.310	.129	#4	.080	72	.040	58
4 @ #000	12 @ #4	2 @ #000	.413	.478	.206	.129	#4	.080	72	.040	58
4 @ #000	10 @ #4	4 @ #000	.413	.399	.413	.144	#4	.080	77	.040	63

Heavy Edge Road Fabric for 20′ 0″ Road

6″x6″ MESH—ALL WIRES SPACED 6 INCH CENTERS

Number and Gauge of Longitudinal Wires: Heavy Wires Outer Edge	Center Wires	Heavy Wires Inner Edge	Sectional Area of Longitudinals in Square Inches: Total of Heavy Wires Outer Edge	Total of Center Wires	Total of Heavy Wires Inner Edge	Average of All Wires Per Foot Width of Fabric	Gauge and Areas of Cross Wires: Gauge	Sectional Areas Sq. In. Per Foot of Fabric	Total Weight of Fabric Lbs. Per 100 Sq. Ft.	Using 12-Inch Spacing of Cross Wires the Sectional Area of Cross Wires and Total Weights of Fabric Are: Sectional Area Sq. In. Per Foot of Fabric	Total Weight of Fabric Lbs. Per 100 Sq. Ft.
2 @ #0	16 @ #6	2 @ #0	.148	.463	.148	.080	#6	.058	47	.029	37
3 @ #0	14 @ #6	3 @ #0	.221	.405	.221	.089	#6	.058	50	.029	40
4 @ #0	14 @ #6	2 @ #0	.295	.405	.148	.089	#6	.058	50	.029	40
4 @ #0	12 @ #6	4 @ #0	.295	.347	.298	.099	#6	.058	54	.029	44
2 @ #00	16 @ #5	2 @ #00	.172	.538	.172	.093	#5	.067	55	.034	43
3 @ #00	14 @ #5	3 @ #00	.258	.471	.258	.104	#5	.067	59	.034	47
4 @ #00	14 @ #5	2 @ #00	.344	.471	.172	.104	#5	.067	59	.034	47
4 @ #00	12 @ #5	4 @ #00	.344	.404	.344	.115	#5	.067	62	.034	51
2 @ #000	16 @ #4	2 @ #000	.206	.638	.206	.111	#4	.080	65	.040	51
3 @ #000	14 @ #4	3 @ #000	.310	.558	.310	.124	#4	.080	70	.040	56
4 @ #000	14 @ #4	2 @ #000	.413	.558	.206	.124	#4	.080	70	.400	56
4 @ #000	12 @ #4	4 @ #000	.413	.478	.413	.137	#4	.080	74	.040	60

The following states are using fabric with heavy wires along the edges of the sheets:
NEW YORK, NEW JERSEY, NEW HAMPSHIRE, OKLAHOMA, PENNSYLVANIA, MISSISSIPPI, CONNECTICUT, LOUISIANA

Recommended Specifications for Roads

Roads: The reinforcement shall consist of a steel wire fabric manufactured from cold drawn wire, finished members of which shall develop an ultimate tensile strength of at least 70,000 pounds per square inch and which shall bend cold 180 degrees around a pin the diameter of which is equal to the diameter of the wire specimen without cracking on the outside of the bent portion.

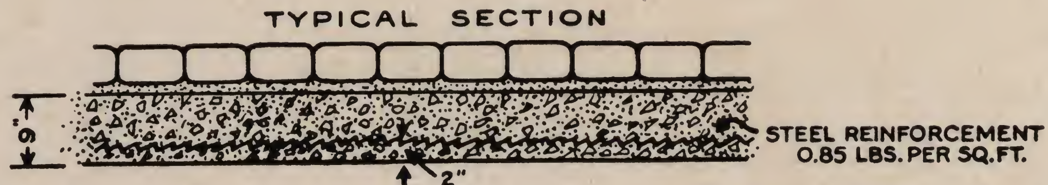
All reinforcement shall be free from excessive rust, scale, paint or coating of any character which will tend to prevent proper bonding of the concrete.

The longitudinal wires of the fabric shall be spaced six (6) inches and shall be No. .... *gauge except .... *wires on each side of the sheet shall be No. .... *gauge. The transverse wires of the fabric shall be spaced .... *inches and shall be No. .... *gauge. The fabric shall weigh not less than .... *pounds per 100 square feet of fabric.

**Local conditions govern. See Tables of "Heavy Edge" Fabric. For average conditions with an 18 foot road use No. 6 gauge longitudinal wires except three wires on each side of sheet shall be No. 0 gauge, and No. 6 gauge transverse wires spaced six (6) inches. Estimated weight 52 pounds per 100 square feet of fabric.*

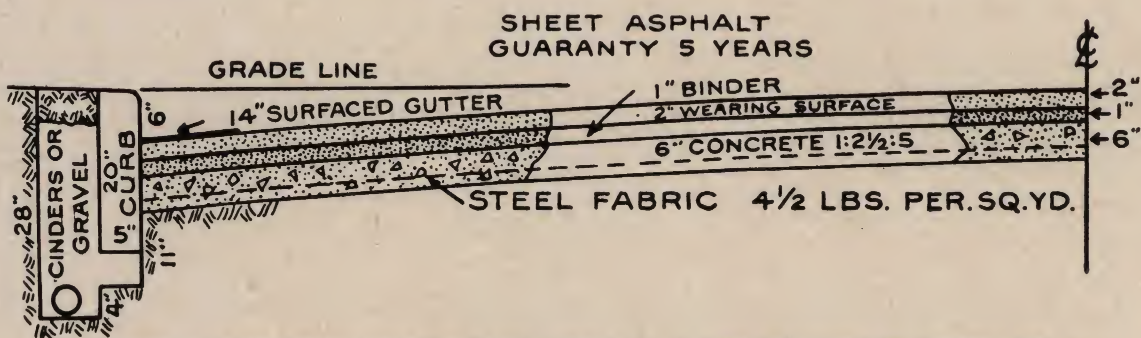
Continued on Next Page

Reinforced Concrete Bases Under Brick, Granite Block or Asphalt Surfaces: The data show that steel reinforcement reduced the rate of cracking and thus increased the life of the pavement. This applies both to concrete pavements and other pavements laid upon a concrete base."—Report of the Investigation of the Economic Value of Reinforcement in Concrete Roads by Highway Research Board of National Research Council.



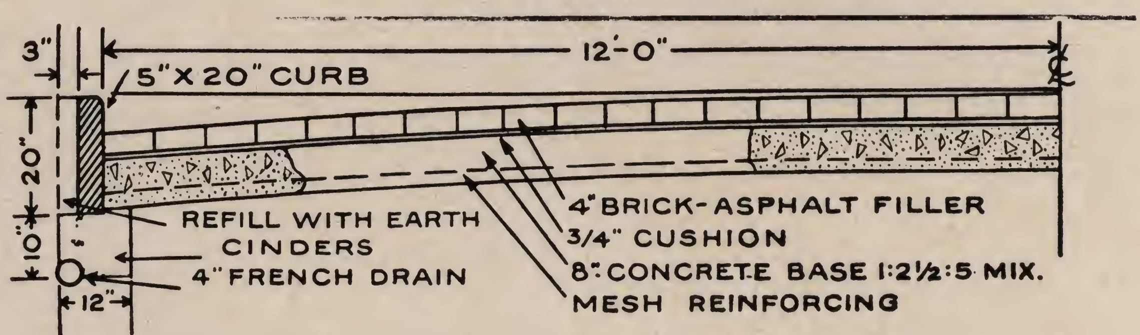
Typical Section for Granite Block on Concrete Foundation, City of New York, Bureau of Manhattan, 11th Avenue

"Reinforcement shall be steel wire fabric similar and equal to that manufactured by American Steel & Wire Co."



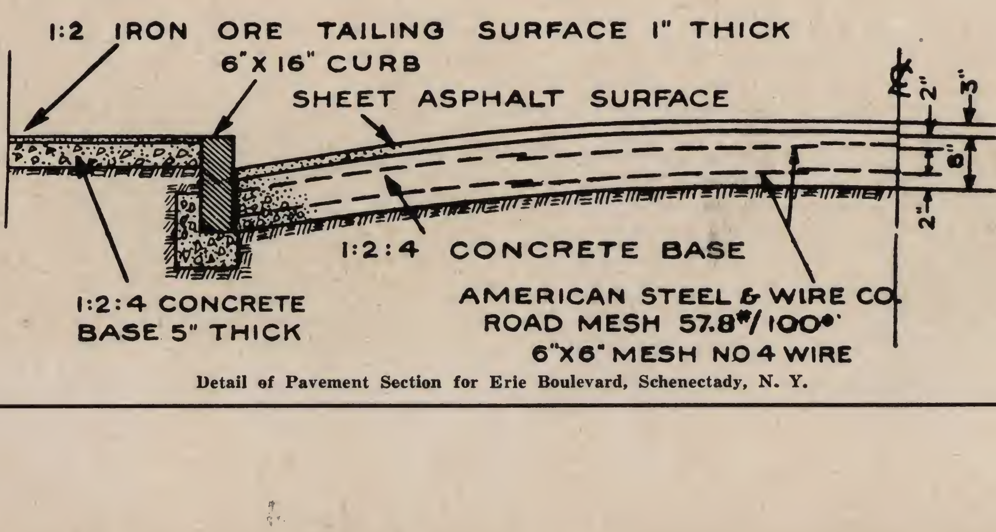
Reinforced Concrete Base—Asphalt Top Typical Design of F. A. Pease Engineering Co., Cleveland, Ohio

For Cleveland Heights, Shaker Heights, Euclid Heights, and other suburbs of Cleveland



Reinforced Concrete Base—Brick Top. Typical Specifications for Cuyahoga County, Ohio

They use 59 lb. wire fabric in all types of pavements. Frank R. Lander, County Engineer



Detail of Pavement Section for Erie Boulevard, Schenectady, N. Y.

CONCRETE ENGINEERING CO.

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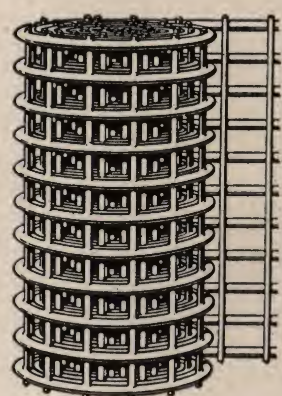
TRADE MARK

Ceco

Quick Fabrication and Shipment of All Ceco Products:—Ceco Welded Fabric, Ceco Triangle Fabric, Ceco Contraction Center Road Strip, Ceco Reinforcing Bars, Ceco Bar Supports, Ceco Stake Pins.

Other Ceco Products are: Meyer Steelforms, Meyer Adjustable Shores, Meyer Adjustable Column Clamps, Ceco flat and ribbed Metal Lath, and other reinforced concrete construction products.

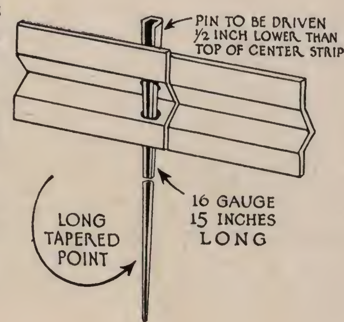
Ceco Contraction Road Strip: Ceco Contraction Center Road Strip is made to accommodate any depth of slab. Holes are punched for transverse bars and stake pins as may be specified by any state, county or city. Made of No. 18 and No. 16 gauge steel and furnished either painted or unpainted. The drawing below shows Ceco Center Strip as used in slab.



Ceco Welded and Triangle Fabric are valuable aids in lengthening the life of any pavement. The disintegration and failure of any concrete road or street is caused by cracking. Test reports of the Highway Research Board show that the cracking of concrete paving is most economically prevented by the use of small steel members closely spaced. That is Ceco Fabric.

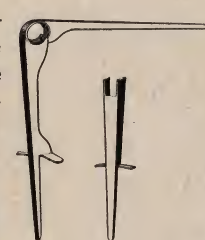
Ceco Welded Fabric: A rectangular fabric of cold drawn wire furnished in all desired gauges and spacings of wires. Available in rolls or cut to specified lengths in flat sheets, in widths up to 8′ 6″, either plain or galvanized.

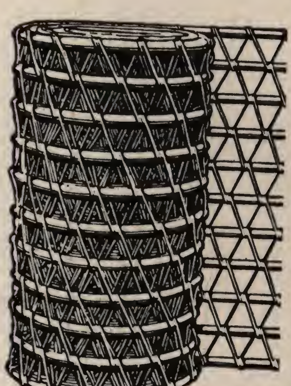
Ceco Stake Pins: It is necessary to provide a pin to be inserted through the holes in Ceco Center Strip and driven into the ground to securely hold center strip in a vertical plane while concrete is poured. Ceco Double Taper Stake pins provide an ideal stake for this purpose.



Ceco Reinforcing Bars: Rolled only from **New Billet** steel and furnished in standard sizes of deformed rounds and squares. All Ceco Reinforcing Bars are tested and inspected by the Robt. W. Hunt & Co., Engineers, to conform to the specifications of the American Society for Testing Materials. You receive a guarantee of quality with every bar. Test reports furnished on request.

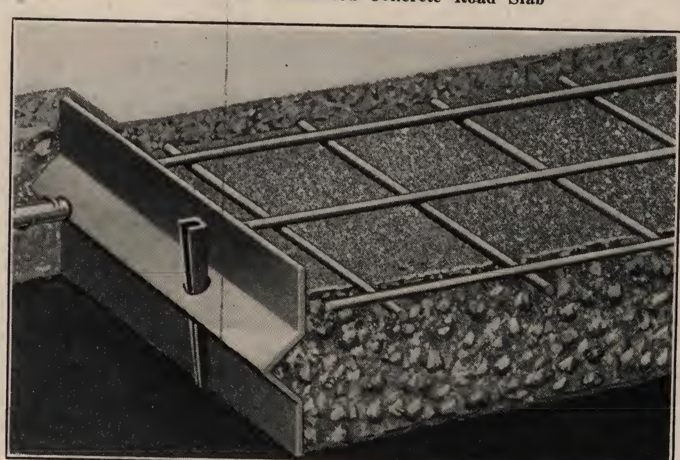
Ceco Bar Supports: Ceco Bar Supports are made of 22 and 20 gauge sheet steel. They properly space reinforcing bars the required distance from outside edge of slab and hold them in correct position while concrete is poured. Made in standard height, to support transverse and longitudinal reinforcing bars.





Ceco Triangle Fabric: A woven fabric with the longitudinal wires spaced 4″ c.c. The diagonal cross wires spaced 4″ and 8″ c.c. The longitudinal wires may be of any gauge from No. 12 to No. 2, the cross wires are always No. 14 for some style and No. 12½ for others. Available in widths from 16″ to 56″ and in rolls or cut to specified lengths in flat sheets, either plain or galvanized.

The Sketch Below Shows Ceco Electrically Welded Fabric, Center Parting Strip, Stake Pin and Dowel Bar, as Used in Modern Type of Reinforced Concrete Road Slab



CONCRETE STEEL COMPANY

42 Broadway, New York, N. Y.

Concrete Reinforcement for Road Construction

SALES OFFICES.

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New York	Philadelphia	Pittsburgh	Minneapolis	Jacksonville	Omaha
	Washington	Detroit	St. Paul		

WAREHOUSES AND FABRICATING WORKS.

Boston	Camden	Washington	Detroit	St. Paul	Wichita
New York	Birmingham	Youngstown	Chicago	Kansas City	Jacksonville

Products: Havemeyer Welded Barmats and Highway Reinforcement of Every Type, Installing Devices, Bar Tys, Supporting Chairs, Pressed Metal Joint Plate or Parting Strip, Pressed Pins, Cap Strip, Welded Mesh in Rolls and Flat Sheets, Shop Bent Reinforcement for Highway Bridges of Every Type, Curb Bar and Premoulded Asphalt Joint.

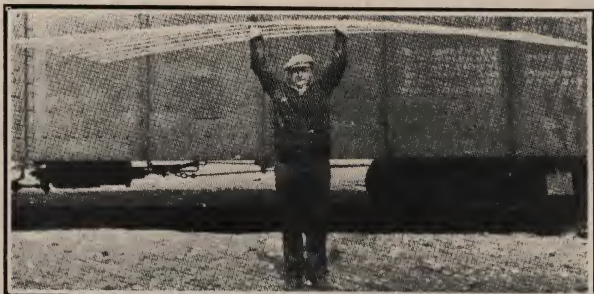

Fig. 1. Electrically welded Barmat, 8 ft. 8 in. by 14 ft. long. Note remarkable stiffness and ease of handling

New Type of Steel Reinforcing for Highways: An electrically welded mat of deformed bars has been developed which is rapidly superseding hand assembled mats made on the job.

Advantages: Havemeyer Barmat is delivered on the job in units of various sizes and weights, to specification, up to 11′ wide by 20′ long. They do away with hand assembly. Welded joints give them remarkable stiffness. **They are easy to place and support accurately in the road.** ⅜″ round deformed bars are standard, but other weights can be supplied. They have great flexibility of design. Any variation can be obtained. The cost of handling and installing shows such a marked saving that they more than justify a slight premium in price.

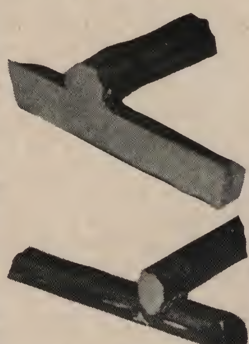

Fig. 2. Detail of Weld used in Barmats and section through Weld

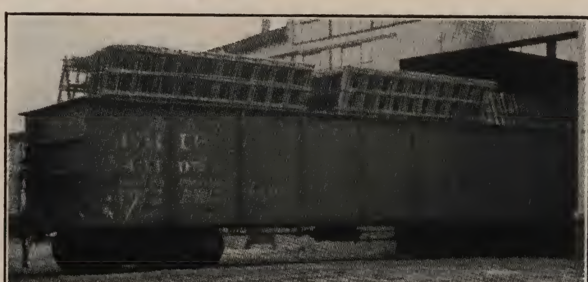

Fig. 3. Method of shipping wide sheets in high side cars

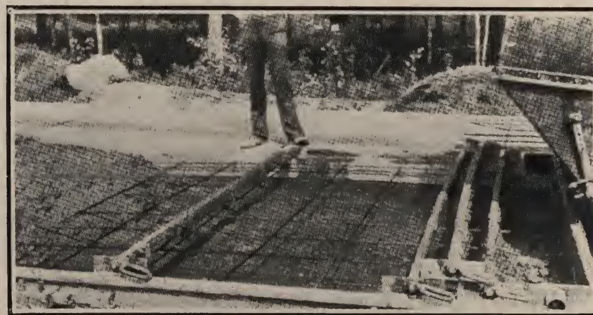

Fig. 4. A view showing excellent and accurate placement of steel secured by this method

Types of Reinforcement Recommended: For city streets on good subgrades in frost areas, use reinforcement weighing at least 70 lbs. per 100 sq. ft., two inches below the surface, transverse joints 60 to 80 ft. apart. For state and county highways, use two layer reinforcement, at least 50 lbs. to each layer, with transverse joints 60 to 80 ft. apart. Full width construction is recommended where possible, employing the "drag plate" method of center line construction described herewith.

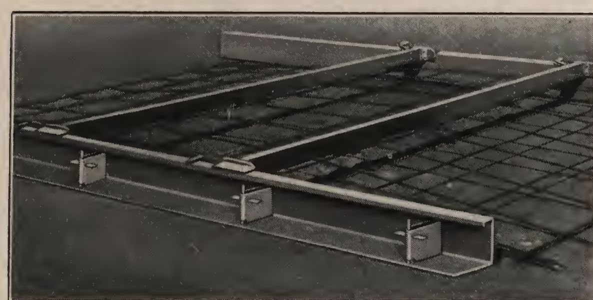

Fig. 5. New Type Installing Device perfected for 1928. Note double operating handles, one at each end. The top of this device is only one inch above top of finished concrete

Installing Devices: Newly developed by our engineering force to meet all conditions. They support the reinforcement until concrete is deposited and up to grade, and greatly reduce the labor of shoveling and spreading concrete. Two men hook up a device in 10 seconds.

Longitudinal Joint in Full Width Construction: Another Concrete Steel development, accomplished by what is called the "drag plate" method. Makes a beautifully straight groove ⅜ in. wide by 2¼ in. deep in the surface of wet concrete, ready to take a precast asphalt joint while the concrete is still soft. Three 16 ft. lengths of steel plates, supported upon chairs or installing devices are drawn by the concrete mixer, leaving

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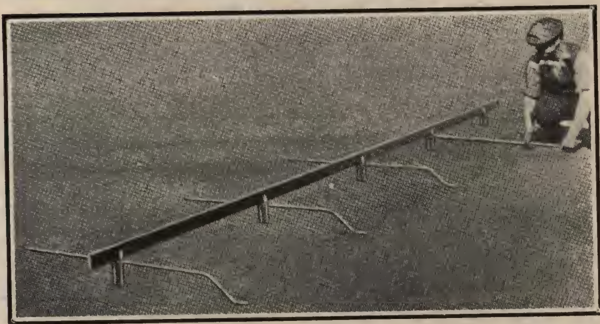

Fig. 6. Drag Plate on Tangent supported on chairs. Note that dowels may be inserted after chairs are set if necessary

a tunnel or slot for the precast asphalt joint. Forms a better center joint. Patents are applied for.

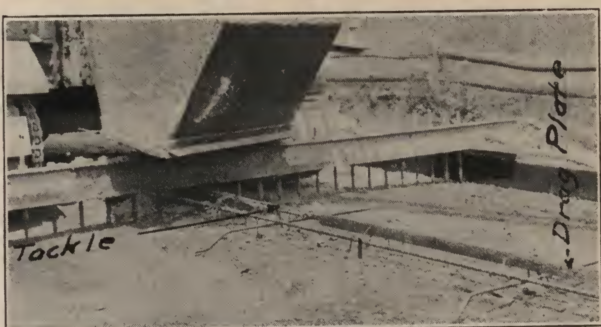

Fig. 7. View behind mixer showing scratch board, center reinforcing unit, dowels and Drag Plate with cable connection to mixer

Fig. 8. Sections showing one method of installing and finishing Precast Asphalt Joint in slot left by Drag Plate

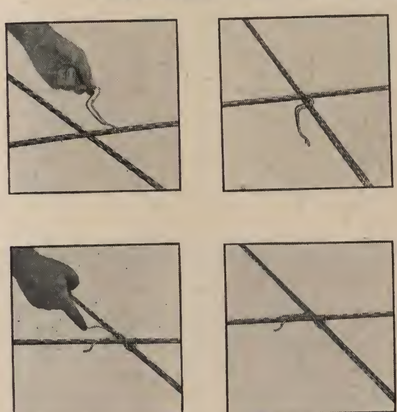

Fig. 9. Havemeyer No. 4 Bar Ty

Bar Tys and Chairs: Havemeyer Bar Tys for tying reinforcing bars together are especially adapted for road work. They are much stronger than tying wire and faster to work with. Pressed Metal Supporting Chairs are furnished in standard sizes, for single or double layer reinforcement.

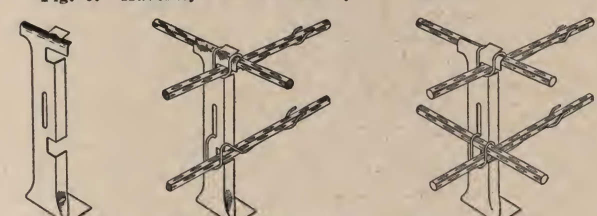

Fig. 10. Pressed Metal Chairs

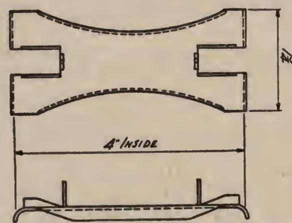

Fig. 11. Pressed Metal Spacer

Pressed Metal Spacers: Stamped from sheet steel and used to assemble and support two-layer reinforcement, which is placed on 2 in. of concrete on subgrade. This type is now standard in New Jersey. See Fig. 11.

Pressed Steel Joint Plate: For highway construction, is regularly carried in stock and can be furnished to meet any specifications. The standard lengths are 10 ft. 2 in. and 15 ft. 2 in., in 18, 16 or 14 gauge.

Fig. 12. Standard Joint Plate

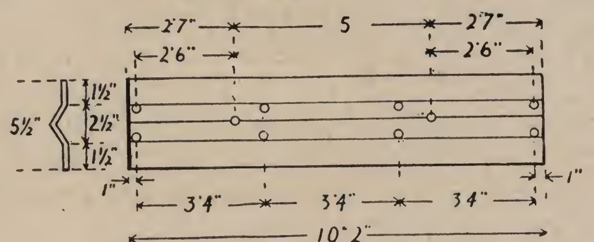

Fig. 13. Standard dimensions for Joint Plate

Round and Angle Nose Curb Bar: Flared anchors spaced every 6 in. provide a positive bond to the concrete curb. Absence of a continuous web eliminates danger of splitting the curb. Angle Nose carried in 10 ft. lengths, galvanized; Round Nose in 8 ft., 10 ft., 12 ft. lengths, galvanized and bent to radius on order.

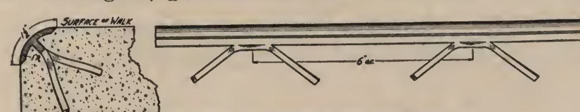

Fig. 14. Round Nose Curb Bar

Havemeyer Bars: In this bar a constant cross-section is maintained and every bit of material is effective in resisting tension or compression. The area, weight and strength of the Havemeyer Bar are exactly the same as those of a plain bar of the same

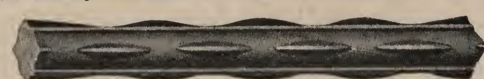

Fig. 15. Havemeyer Round Bar

nominal area. Sizes are those recommended by Concrete Industries Board and adopted as standard by American Concrete Institute and by distributors of reinforcing bars.

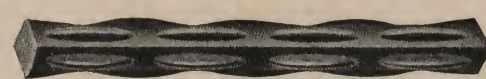

Fig. 16. Havemeyer Square Bar

Size, Round or Square	Area, Sq. In.	Lbs. Per Ft.	Extra for Size Per 100 Lbs.
1¼" sq.	1.563	5.312	Base
1⅛" sq.	1.266	4.303	Base
1" sq.	1.000	3.400	Base
1" rd.	.785	2.670	Base
⅞" rd.	.601	2.044	Base
¾" rd.	.442	1.502	Base
⅝" rd.	.307	1.043	$0.10
½" sq.	.250	.850	.20
½" rd.	.196	.667	.20
⅜" rd.	.110	.376	.40
¼" rd.	.049	.167	1.00

Premoulded Asphalt Expansion Joint: To meet all state specifications. Made from best grades of asphalt and contains a very high percentage of a mixture of fiber. Strong and elastic.

NATIONAL STEEL FABRIC COMPANY

Union Trust Bldg. DIVISION OF Pittsburgh Steel Co. Pittsburgh, Pa.

DISTRICT SALES OFFICES

Atlanta, Ga., 604 Walton Bldg.
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Cincinnati, Ohio, Dixie Terminal Bldg.
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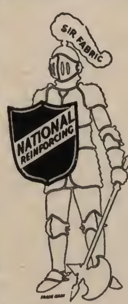
Los Angeles, Calif., 1736 Naud Street.
New York, N. Y., 726 Liggett Bldg., 41 E. 42nd St.
Philadelphia, Pa., Franklin Trust Bldg.
Portland Ore., 350 E. Ankeny Street.
St. Louis, Mo., Railway Exchange Bldg.
San Antonio, Tex., 501 Builders Exchange Bldg.
San Francisco, Calif., 274 Brannan Street.
Seattle, Wash., 2700 Westlake Avenue North.

Warehouses

Los Angeles San Francisco Chicago St. Louis Houston Pittsburgh Philadelphia New York

Products: National Reinforcing—Electrically Welded Cold Drawn Steel Wire Fabric for Reinforcing Concrete Roads and Pavements as Well as Every Kind of Construction Using Plastic Materials Such as Concrete, Cement, Plaster, Stucco, Gypsum, Etc.

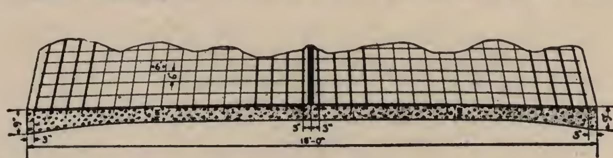


Concrete—reinforced with steel fabric—National Reinforcing—is the ideal road building material. The durability of this type of road construction has been service proven throughout the country, and results of the recent survey by the Highway Research Board* recommend steel fabric reinforced concrete for road building. A road thus laid is permanent—practically free from maintenance expense.

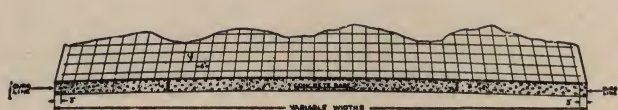
National Reinforcing is an electrically welded fabric or mesh of cold drawn steel wires. Embedded in the concrete, it protects against cracking from heat and cold, expansion and contraction, as well as against the stresses and strains set up when the wet concrete is drying. There are styles to meet the various state and local conditions. National Steel Fabric Company is the world's largest manufacturer of welded steel fabric and as such can promise immediate shipments of your order, whether large or small.

Cross Section of Weld of National Reinforcing illustrating the "fusing" together of Longitudinal and Transverse members.

*Valuable data for Engineering use when designing roads is contained in "Part II, Report of Investigation of the Economical Value of Reinforcing in Concrete Roads," by the National Research Council, Washington, D. C. Write our nearest office for a copy.



Typical Cross Section Showing Use of National Reinforcing in Divided Roads.



Typical Cross Section Showing Use of National Reinforcing for City Streets and Pavements.

RECOMMENDED SPECIFICATIONS FOR ROADS

"Reinforcing fabric shall consist of a welded steel mesh manufactured from cold drawn wire, finished members of which shall develop an ultimate tensile strength of not less than 70,000 pounds per square inch of steel and shall bend cold 180 degrees around one diameter without cracking on the outside of the bent portion."

"The fabric shall be free from excessive rust, scale or coating of any character, which will impair its bond with the concrete."

"The longitudinal wires of the fabric shall be spaced six inches (6″) apart and shall have a sectional area of not less than ....* square inches of steel per foot of fabric for ....† inches from the edges of each sheet and a sectional area of not less than ....* square inches of steel per foot of fabric for the remainder of each sheet. The transverse wires of the fabric shall be spaced six inches (6″) apart and shall have a sectional area of not less than ....* square inches of steel per foot of fabric. The longitudinal and transverse wires shall be welded together at every intersection."

*Local conditions determine the area of steel to be specified.

†Local conditions determine the distance from the edge of sheets for the heavier wire.

NATIONAL REINFORCING—Styles for Split Roads (8′ 6″ Width of Fabric)

Style	Spacing		Gauge of Wires			Cross Sectional Area Sq. In. per Lin. Ft.			Weight per 100 Sq. Ft
	Long.	Trans.	Long.		Trans.	Long.		Trans.	
			6″ Edges	Center		6″ Edges	Center		
4-C06	6″	6″	0	6	6	148	.058	058	48 lbs
			12″ Edges	Center		12″ Edges	Center		
6-C06	6″	6″	0	6	6	.148	058	058	52 lbs
			18″ Edges	Center		18″ Edges	Center		
8-C06	6″	6″	0	6	6	148	.058	058	55 lbs
			6″ Edges	Center		6″ Edges	Center		
4-C005	6″	6″	00	5	5	172	.067	.067	56 lbs
			12″ Edges	Center		12″ Edges	Center		
6-C005	6″	6″	00	5	5	.172	.067	.067	60 lbs.
			18″ Edges	Center		18″ Edges	Center		
8-C005	6″	6″	00	5	5	172	067	.067	64 lbs

RECOMMENDED SPECIFICATIONS FOR CITY STREETS

"Reinforcing fabric shall consist of a welded steel mesh manufactured from cold drawn wire, finished members of which shall develop an ultimate tensile strength of not less than 70,000 pounds per square inch of steel and shall bend cold 180 degrees around one diameter without cracking on the outside of the bent portion."

"The fabric shall be free from excessive rust, scale or coating of any character which will impair its bond with the concrete."

"The longitudinal wires of the fabric shall be spaced six inches (6″) apart and shall have a sectional area of not less than ....* square inches of steel per foot of fabric. The transverse wires of the fabric shall be spaced six inches (6″) apart and shall have a sectional area of not less than ....* square inches of steel per foot of fabric. The longitudinal and transverse wires shall be welded together at every intersection."

*Local conditions determine the area of steel to be specified.

NATIONAL REINFORCING

Styles for City Streets and Concrete Bases

Style	Spacing		Gauge of Wires		Cross Sectional Area Sq. In. per Lin. Ft.		Weight per 100 Sq. Ft.
	Long.	Trans.	Long.	Trans.	Long.	Trans.	
CC77	6″	6″	7	7	.049	.049	36 lb
CC66	6″	6″	6	6	058	.058	42 lbs.
CC55	6″	6″	5	5	067	067	49 lbs.
CC44	6″	6″	4	4	080	080	58 lbs.
CC33	6′	6″	3	3	093	093	68 lbs.
CC22	6″	6″	2	2	.108	108	78 lbs.

Write our nearest office for prices on various styles, weights and areas.

WICKWIRE SPENCER STEEL COMPANY

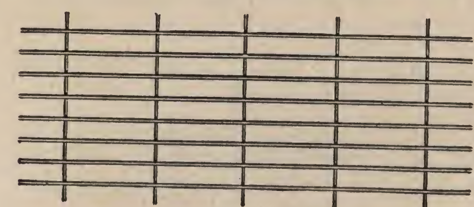
41 East Forty-second Street, New York

Manufacturers of Road Reinforcement and Highway Guards

Worcester Buffalo Cleveland Detroit Chicago San Francisco Los Angeles Seattle

Products: Clinton Electrically Welded Fabric for Concrete Road Reinforcement and Highway Guards.

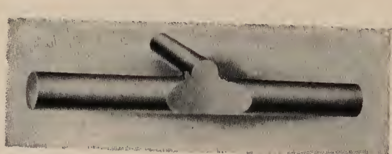
Clinton Welded Fabric: This fabric forms an ideal and economical reinforcement for nearly every form of concrete construction. Its cold drawn steel wires are electrically welded into rigid, strong connections making positive, perfect alignment of its transverse and longitudinal members. It gives support to the structure at all points of stress. By welding connections all waste material has been eliminated. There are no wraps, clips or bindings to interfere with the even flow of the concrete. Freedom from voids is thereby insured.



Sheet of Clinton Welded Fabric.

Note the perfect alignment of the wires and efficient manner in which all wires are held in their proper relative positions.

Clinton Electrically Welded Fabric can be laid quickly and easily with the assurance that every wire will be in its proper place. It is furnished in widths desired, saving much time and expense in re-cutting and adjustment of wires.



The Clinton Electric Weld.

In this view the two wires have been cut through at their point of union, revealing a perfectly smooth surface. It is a perfect weld; the two wires are actually fused together.

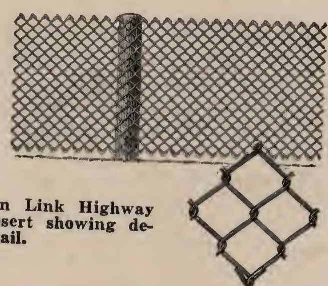
Manufacturing Limits: Size of wires: Longitudinal or transverse strands may consist of Nos. 0 to 13, inclusive, Washburn-Moen gauge wires. When the same size wire is not required in both members of the fabric, the heavier size may be placed either longitudinally or transversely although structural requirements in such cases usually call for the heavier wires in the longitudinal strands.

Spacing of Wires. Longitudinal wires may be spaced on centers of 2 or more inches in steps of 1 inch. Transverse wires may be spaced on centers of 2 to 10 inches in steps of 1 inch and on centers of 10 to 18 inches in steps of 2 inches.

Widths. Widths of fabric as measured from center to center of outside longitudinal wires cannot, in any case, exceed 100 inches. Transverse wires must project at least ½ inch beyond the outside longitudinal wire but may have any specified projection in excess of ½ inch provided their total tip-to-tip length does not exceed 102 inches.

Rolls or Sheets. Welded Fabric may be furnished either in rolls or flat sheets. It is necessary that fabrics having longtiudinal wires heavier than No. 2 gauge be shipped always in sheets. The size of sheets should not exceed 6x20 feet if shipped in box cars, or 8x32 feet if shipped in open-top cars. Rolls may be of any desired length not exceeding 150 feet for heavy sizes, 200 feet for medium sizes and 400 feet for the light sizes.

Finish. Welded Fabric is furnished both in "Plain Steel" and "Galvanized" grades. Galvanized fabric is not galvanized after fabrication, but is manufactured into mesh form by using galvanized wire instead of plain wire.



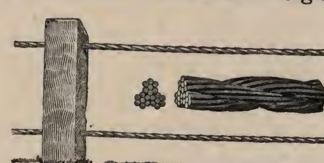
Excelsior Chain Link Highway Guard with insert showing detail.

Excelsior Chain Link Highway Guard: This forms the best protection at danger spots on highways that can be erected at low cost. Excelsior Chain Link Highway Guards stretch under impact, minimizing damage to automobiles in accidents. Cars will not break through them.

Heavy hot galvanizing after weaving, a process *first* developed by Wickwire Spencer, gives the pickets thorough protection against rust. They will give long service without painting and with minimum repairs.

Additional protection to motorists is provided by these guards clearly marking the road at night with their silvery gleam under headlights.

Made of fine, specially drawn steel wire of high tensile strength in 2 in. meshes. Standard heights and gauge.



Strong and durable protection is furnished by Extra Galvanized Strand Highway Guard. Insert shows detail and cross-section view of rope.

Extra Galvanized Strand Highway Guard: Constructed from three strands of seven wires each. As a highway guard it has more than ample strength to meet the severest emergency demands resulting from automobile accidents or other causes. Its extra heavy coating of zinc gives it durability and excellent protection against rust.

Admixtures in and Curing of Concrete

DIATOMACEOUS SILICA AS AN ADMIXTURE.—As a means for increasing the workability of concrete, Celite, a specially prepared form of diatomaceous silica is attracting considerable attention from those engaged in the fabrication of field concrete.

This material is furnished in the form of a light weight powder in an extremely finely divided state which is added at the mixer with the other materials. Being composed almost entirely of pure amorphous silica (SiO_2), it is a permanent element in concrete and does not affect the time of setting. The percentage of diatomaceous silica which should be added for best results varies with the mix and with the nature of the aggregate. The quantities recommended by the manufacturer are indicated in the table below:

Percentage of Celite (Diatomaceous Silica Added by Weight of Cement

Concrete Mix	Economic Limits	Recommended Average
1:1⅛:3	1½-3% Celite	2% Celite
1:2 :4	2 -4% "	3% "
1:2½:5	3 -6% "	4% "
1:3 :6	4 -8% "	5% "

In general, more of the admixture is required for the leaner mixes, although in any case the amount constitutes only a very small proportion of the entire mixture.

Among the advantages claimed for diatomaceous silica are the following:

By the use of diatomaceous silica, concrete of much drier consistency and at the same time one of high workability is assured. Only sufficient water should be used to insure a thorough mixing of the mass into a workable consistency. In general, it will be found that by the use of diatomaceous silica the desired degree of workability can be secured with a drier consistency than is the case with plain concrete. For instance, for a given mix and quantity of mixing water concrete containing diatomaceous silica will show a slump of 2 in. as compared to 4 in. for plain concrete; yet, the concrete containing diatomaceous silica with the lower slump will have a much greater workability.

Due to the drier consistencies which can be employed when diatomaceous silica is used, the strength of the concrete is naturally increased.

The use of diatomaceous silica greatly increases the plasticity of the mix and holds the ingredients in suspension, effectively preventing segregation. This is the opposite effect to that secured when workability is attempted by the use of excess water. Due to the high workability and prevention of segregation the use of diatomaceous silica makes central mixing a thoroughly practical operation and also greatly facilitates the handling of concrete through chutes. By preventing segregation and insuring uniform distribution of the cement, the effective slab thickness in concrete pavements is considerably increased.

Diatomaceous silica as an admixture increases the watertightness of concrete in two ways; first, by insuring more uniform concrete and a uniform distribution of voids throughout the mass; and second, by decreasing the void size which is a function of the extreme fineness of the material.

Due to the light weight and extreme bulkiness of this admixture its use results in an increased yield of finished concrete in place.

USE OF CAL AND PORTLAND CEMENT IN PATCHING CONCRETE ROADS.—Roads and Streets, February, 1926, gives the following:

Patching concrete roads presents problems which are so decidedly different from those met in new construction that new materials and new techniques are constantly being tried and developed to meet the demands of this type of work. By patching is meant the repair of small breaks, usually at corners or edges of the road, which may be repaired without detouring traffic. This term may also apply to repairs across the whole width of a road when the break is narrow enough to allow bridging.

After five years' experience with cal (calcium oxychloride) and its use in all classes of concrete construction, a road patching method has been developed which gives with cal and portland cement a patch which is stated to be "self curing" and to allow full traffic within 24 hours. In addition the technique is said to be so simple that good results may be obtained without expert supervision. The method is as follows:

Preliminary Work.—(1) Remove broken concrete where the patch is to be placed, and break the edges of the permanent concrete so that a fresh surface is exposed for bond with the patch. (2) Excavate the subgrade to give a total thickness of nine or ten inches to the patch. (3) Tamp the subgrade thoroughly. (4) Wet the subgrade. (5) Wet the edges of the old concrete.

Mixing the Concrete.—Using clean, dry, well graded aggregates, mix a 1:1½:3 concrete, using 8 lbs. of cal per bag of cement. Use only 5 gal. of pure mixing water per bag of cement, and mix it for 5 minutes.

Placing the Concrete.—Place the resulting dry concrete in the area to be patched and tamp thoroughly to grade. Tamp with special care at the edges of the patch where it must bond with the old concrete.

Curing.—After the patch is finished paint the exposed surfaces of the patch and the old concrete for 6 in. on all sides of the patch with a slurry of cal and water. In preparing the slurry mix 5 lbs. of cal with 1 gal. of water and stir vigorously for a few minutes. This mixture is enough for 150 sq. ft. of surface. After the surface has been painted with cal the patch will not require further attention. In moderate or summer weather traffic may run over the patch in 24 hours. When the temperature is below 40° and above freezing two days should be allowed.

Cal is a powder which is added dry with the cement and aggregates. Its pure white color is insurance against an untreated batch. It can be accurately measured by volume, a gallon measure holding 8 lbs. of cal. A conscientious foreman can be trusted to see that each batch is made strictly according to the directions.

USE OF CALCIUM CHLORIDE FOR MAKING QUICK HARDENING CONCRETE.—In a paper on methods of repairing concrete roads, presented at an annual conference of Mississippi Valley State Highway Department, A. H. Hinkle, Superintendent of Maintenance, Indiana State Highway Department, gave the following particulars regarding the making of quick hardening concrete by the addition of calcium chloride whose chemical symbol is $CaCl_2$.

Quick hardening concrete made of ordinary Portland Cement depends for its early strength upon: (a) richness of the mix, (b) freedom from excess water, (c) use of $CaCl_2$, (d) comparatively high atmospheric temperature when curing, (e) time of mixing, (f) use of coarse sand and a properly graded aggregate. By taking advantage of all of the above five factors which affect the time of hardening, in one mixture, it is possible to make a concrete patch of ordinary portland cement which can be opened to traffic two days after it is laid.

Richness of Mix.—The proportion of cement that should be used to secure a patch which can be opened to traffic after any number of days is shown in Table 1 It will be observed from this table that to secure a patch which can be opened to traffic after two day's time, the proportion should be, 1 bag of cement, 0.5 cu. ft. sand, 1.9 cu. ft. coarse aggregate, 2 lbs. $CaCl_2$, and only enough water to produce a slump in the concrete of about 1 in. Other proportions which should be used in making a patch that can be opened to traffic after any number of days are found in the table. This table is based, in a general way, on data furnished by Mr. Duff Abrams of Lewis Institute, Chicago, Illinois. The compressive strength of the mix when it is to be opened to traffic is about 3,000 lb. per square inch with an atmospheric temperature of 70° F.

Table I—Mix or proportions of materials to use to secure concrete that can be opened to traffic after any number of days.

PROPORTIONS

Days Patch closed to Traffic. (1)	Bags of Cement. (2)	Cu. Ft. of Sand (0-¼"). (3)	Cu. Ft. of Coarse Aggregate (½"-2½"). (4)	Lbs. $CaCl_2$ or Qts. of Standard Solution." (5)	Water — Add enough to produce Slump given below. (6)	Bags of Cement per Cu. Yd. of Concrete. (7)	Remarks (8)
2	1	0.5	1.9	2	1 "	11.8	This mixture to be used for small patches that are to be opened to traffic at the earliest date possible. Atmospheric temperature should average about 60° F.
3	1	0.6	2.1	2	1 "	11.2	
5	1	1.0	2.7	2	1½"	8.4	
12	1	1.3	3.0	2	1½"	7.6	Standard Mix to be used where closing road to traffic is not an important item and where large areas are to be patched.
15	1	2.0	3.0	2	1½"	6.8	
21	1	2.0	3.0	No Ca Cl_2	2½"	6.8	

(5) This "Standard Solution" is made by dissolving commercial $CaCl_2$ in water at the rate of one (1) pound to enough water to produce one (1) quart of solution. The pure $CaCl_2$ should never be added direct to the drum of the mixer. The" Standard Solution" should be added to the water just before it is put into the drum. See instructions under Calcium Chloride.

(6) Standard Slump Test. Fill with concrete a metal form shaped as a frustum of a cone. Form should be 12 in. high with a 4 in. top diameter and 8 in. base diameter. Set the form on a level surface and as the concrete is put in the form, tamp lightly with a rod until a slight film of mortar appears on the surface. Then remove the form and immediately note the settlement or slump of the concrete which is a measure of its consistency.

In order to secure the max strength of concrete, it is necessary to use a dry mix. While a dryer concrete than a 1 in. slump will give greater strength it is impractical to make a patch from too dry a mix and hence a 1 in. slump is recommended as being the driest mix that it is practical to use.

Use of Calcium Chloride.—The addition of calcium chloride to concrete quickens the time of hardening. The addition of 2 lb. of $CaCl_2$ per sack of cement adds about 40 per cent to the strength of concrete two days old. Hence, the value of the $CaCl_2$ in a quick hardening concrete. While 3 lb. of $CaCl_2$ to a sack of cement seems to give a maximum strength, the additional strength of 3 lb. over 2 lb. is small. Also, more than 3 lb. starts to reduce the strength. Hence, it is deemed advisable to use about 2 per cent $CaCl_2$ in making the quick hardening concrete. The calcium chloride should not be added directly to the concrete but should be made in the form of a "standard solution" of about 2 lb. of calcium chloride to 2 qts. of water and this solution put in the drum of the mixer with the rest of the mixing water.

High Atmospheric Temperature.—To secure quick hardening concrete of ordinary Portland cement, advantage must be taken of the accelerated hardening due to comparatively high atmospheric temperatures. For instance concrete cured at 40° F. will have only about 70 per cent of the strength if cured at 70° F. when cured at 80° F. it will have about 105 per cent of its strength if cured at 70° F.; etc.

Since the strength of concrete is increased by increasing time of the mix up to a certain limit, it is desirable to take advantage of this in producing a quick hardening concrete by extending the time of mix to at least 2 minutes.

A coarse sand that meets the specification for good concrete work will produce a concrete that is stronger in its early stages than the concrete produced from the finer sand. A properly graded aggregate also adds to the strength of concrete. Hence the extreme importance in producing this "quick hardening" concrete of having a well graded aggregate and a good quality of course sand.

Mixing Concrete.—Only machine mixed concrete should be used. In practice, it is almost impossible to produce a uniformly maximum strength concrete, which is very imperative in repair work, if one depends on hand mixing. The usual time specified for mixing ordinary concrete in a mixer is 1 minute. However, tests show that the strength of a dry mix may be increased as much as 10 per cent by mixing 1½ minutes instead of 1 minute and the strength is slightly increased by extending the time to 5 or 10 minutes. In repair work where there is used a small mixer which will generally be less efficient than the big paving mixer and where a dry mix is required for a max strength and quick hardening concrete, the time for mixing might well be placed at not less than 2 minutes. Where it is extremely important that a high strength be secured at the earliest date possible and only small quantities of concrete are required, it should be mixed 5 minutes. This increased time of mixing will also make the finishing easier.

Placing and Finishing Concrete.—Concrete should be shoveled in place and thoroughly tamped. The secret of the early strength of the concrete will largely lie in a comparatively dry mix hammered in place. A 10 lb. concrete tamper can be used for much of this work. A thin edged tamper having a face, say, 1 in. x 4 in. should be available for tamping in narrow openings and along the edge underneath the old slab.

The concrete patch should be finished with a straight edge, template, and a wood float, to a regular and uniform surface to fit the crown and edge of the surface of the old pavement. The straight edge should be used longitudinally on the new concrete where the patch is not too long to do so. Where a full width of pavement is being replaced for a length greater than the length of the straight edge, a template cut to the proper crown of the road should be used. This template can be used both as a cutting edge and tamper to produce a uniform surface. At either end of such a patch a straight edge should be used longitudinally to insure a proper and uniform junction of the new concrete with the old pavement.

With a dry mix and quick hardening mix it will be necessary to finish the surface before the mix stiffens to any appreciable extent. Too long a delay in finishing may make it impossible to make a good finish and will greatly add to the cost of the work.

The concrete containing $CaCl_2$ does not need the protection which ordinary concrete needs. However, it is best to furnish protection to the concrete with a damp cover for one-half the time the new patch is protected against traffic.

Curing Concrete Pavement

Specifications Alabama State Highway Department

CURING CONCRETE.—The finished concrete may be cured by covering the pavement with earth and maintaining as hereinafter provided, by ponding, or by surface application of Calcium Chloride or Sodium Silicate. The Contractor shall be required to stipulate the method he desires to use and obtain the written approval of the Engineer for its use.

Earth Curing.—After the removal of the burlap, and the completion of the finishing operations, the entire surface, including sides of pavement and to a width of twelve (12) inches outside the edges, shall be wetted thoroughly and covered with earth or other approved material to a depth of not less than two (2) inches. This material shall be kept soaked with water for ten (10) consecutive days, and shall remain on the concrete for a period of not less than eighteen (18) days. The pavement shall be protected from traffic as provided in the paragraph on finishing.

For each one thousand (1,000) feet of concrete pavement which has been laid less than ten (10) days there shall be at least one man provided with at least one hundred (100) feet of hose who shall devote his entire time to watering the concrete pavement and its earth covering. The water supply pipe line shall be provided with taps and hose connections not more than two hundred (200) feet apart and at least twenty (20) pounds per square inch pressure shall be applied to each tap.

After the foregoing period of eighteen (18) days has elapsed, the covering of the concrete shall be removed, and the surface of the pavement thoroughly cleaned by sweeping. After twenty-one (21) days the roadway may be opened to traffic, but not until the pavement has been thoroughly cleaned.

Ponding.—The method of curing known as ponding may be used if desired and permitted, the entire surface of the concrete being maintained inundated in at least one (1) inch of water for ten (10) days, but shall not be opened to traffic in less than twenty-one (21) days.

Calcium Chloride.—The surface shall be uniformly covered with flaked or granulated calcium chloride, applied at the rate of not less than two (2) and not more than two and one-half (2½) pounds per square yard of pavement, spread by a squeegee or suitable mechanical device so that a uniform distribution is obtained. Spreading by means of shovels and brooms will not be permitted. All lumps shall be broken and uniformly distributed over the pavement or entirely removed.

It shall not be applied until a period of at least sixteen (16) hours has elapsed after the pavement is laid, and not later than ten o'clock A. M. of the day following the placing of the concrete. It shall not be applied during a rain. If rain falls within a period of three (3) hours following the application of the chloride, an additional application must be made in the same quantity as above specified. Should patches or sections of the concrete after the application of the calcium chloride, appear to be dry, an additional application shall be made when directed by the Engineer, over such patches or sections in order to obtain efficient and uniform covering.

***Sodium Silicate.**—The surface shall be uniformly covered with a mixture consisting of three parts of sodium silicate and one part of water by volume. This mixture shall be slushed on the concrete as soon as the burlap covering required in the paragraph on finishing has been removed, at the rate of not less than one (1) pound per square yard of surface. It shall then be spread evenly over the surface with a soft fibre push broom.

It shall not be applied until a period of at least sixteen (16) hours has elapsed after the pavement is laid and finished and not later than ten (10) o'clock A. M. of the day following the placing of the concrete. It shall not be applied during a rain. If a rain falls within a period of six (6) hours after the application of the sodium silicate, a second treatment shall be applied. Should patches or sections of the concrete, after the application of the sodium silicate, appear to be not covered, an additional application shall be made when directed by the Engineer in order to secure efficient and complete covering.

**Specifications Maryland State Road Commission:*

As soon as the concrete has set up sufficiently to hold the weight of a man without marking it, the burlap will be removed and Silicate of Soda, composed of one part of Soda Ash (Na_2O) to 3.25 parts of Silica (SiO_2) and having a density of from 41° to 43° Baumé, will be applied as follows: Three (3) parts of Silicate of Soda to one (1) part of water measured accurately by volume will be placed in a mixing barrel, stirred thoroughly, and then applied with buckets to the concrete by pouring or sprinkling on the surface and spreading evenly and lightly with a soft bristle brush, squeegee or broom in sufficient quantity to completely cover and not run off the concrete. The sides or edges will be treated with undiluted Silicate of Soda. Approximately one (1) pound of Silicate of Soda is required to treat one (1) square yard of surface. Concrete that has not set up sufficiently at the end of the day to receive this treatment, must be treated the first thing the following morning. In no case will Silicate of Soda be applied when there is any surface water on the concrete. If enough rain should fall to wash off the Silicate of Soda within six (6) hours after it has been laid, a second treatment of the same consistency as the first will be given. After the Silicate of Soda has set, there is no sprinkling or work of any kind necessary to be done to the surface.

CELITE PRODUCTS COMPANY

Manufacturers of Celite, Filter-Cel, Super-Cel, Sil-O-Cel

11 Broadway, New York. 225 E. Superior St., Chicago. 1320 South Hope Street, Los Angeles.

Celite Products Limited, New Birks Building, Montreal, Canada.
Celite Products Corporation, 147 Windsor House, Victoria St., Westminster, London, England.

OFFICES AND WAREHOUSES

Baltimore, 601 Emerson Tower Bldg.
Boston, 79 Milk Street.
Buffalo, Genessee Bldg.
Cincinnati, Neave Bldg.
Cleveland, Bulkley Bldg.
Denver, Symes Bldg.
Detroit, Book Bldg.
Houston, West Bldg.
Kansas City, 222 Lathrop Bldg.
Seattle, 468 White-Henry-Stuart Bldg.
New Orleans, Whitney Central Bank Bldg.
Philadelphia, Bulletin Bldg.
Pittsburgh, Keenan Bldg.
St. Louis, Railway Exchange Bldg.

CELITE FOR CONCRETE INCREASES WORKABILITY AND PREVENTS SEGREGATION DURING HANDLING AND PLACING, INSURING GREATER UNIFORMITY, HIGHER EFFECTIVE STRENGTH, WATER-TIGHTNESS AND DURABILITY.

CELITE
Insures Better Concrete at Less Cost

Celite is a dry powder composed of extremely fine particles of amorphous silica. Added to a concrete mixture with the other dry materials it stabilizes the mass, holding the portland cement, water, sand and coarse aggregate in the same relation to each other throughout handling and placing as when they left the mixing drum.

Improved Workability: The first benefit of Celite in a concrete mixture is improved workability. It obviates the use of excess mixing water and makes it possible to successfully place concrete of drier consistencies.

Comparing the workability given by Celite with that obtained through the use of other agents, Messrs. Pearson and Hitchcock state in their paper, "Economic Value of Admixtures," which was presented before the American Concrete Institute in 1924. "The workability of any concrete mixture is about equally benefited by one part of Celite, two parts of Kaolin, or three parts of hydrated lime such as used in these tests, if the consistency as measured by the flow table is kept constant. . . . For example, in a 1:2:4 mixture the maximum percentages of admixtures to be recommended are about 4% of Celite, 8% of Kaolin, and 12% of hydrated lime, by weight of cement. The improvement in workability which is effected by these maximum additions, is about that which should be expected from a 25% increase in the cement content."

What Improved Workability Means:

1. It results in quicker and cleaner discharge from the mixer.
2. The concrete can be placed with less labor and manipulation.
3. The concrete will flow into place in the forms around intricate reinforcing, completely filling all corners and recesses.
4. Relatively dry concrete can be satisfactorily handled by chutes without the need for excess water.
5. In cases where central mixing is employed no segregation will be encountered in transit from the mixer to the job, and difficulties in dumping from trucks will be eliminated.

Loading Central Mixed Concrete Made with Celite. Note Uniformity and Absence of Free Water

Uniformity and Strength: Segregation is the principal cause of non-uniformity in a concrete structure. It can be absolutely overcome through the correct use of Celite so that the minimum strength (which is in fact the effective crushing strength of the concrete) is greatly increased.

Water-tightness: Celite provides integral water-tightness in concrete in which it is used—a result of improved uniformity and decreased void-sizes.

Increased Yield: The cost of Celite in many cases is repaid alone by the increased yield of finished concrete in place. In a 1:2:4 mix, for example, 3 pounds of Celite per bag of portland cement results in an increase in the yield of concrete of approximately 5 per cent.

Method of Use: No changes of equipment or in methods of mixing or placing concrete are involved in the use of Celite. This powdered material is simply added with the other dry ingredients at the mixer. The mix is handled in the usual manner.

Quantities Used: The quantity of Celite which should be used to secure best results varies with the mix. Harsh aggregates may require a slight increase over the amounts specified. In any case, however, the amount of Celite constitutes only a very small proportion of the entire mixture.

Amounts of Celite Added Per Bag (94 lbs.) of Cement

Concrete Mix	Economic Limits	Recommended Average
1:1½:3	1½-3 lbs. Celite	2 lbs. Celite
1:2½:3½	2-4 lbs. Celite	3 lbs. Celite
1:2:4	2-4 lbs. Celite	3 lbs. Celite
1:2½:5	3-6 lbs. Celite	4 lbs. Celite
1:3:6	4-8 lbs. Celite	5 lbs. Celite

Standard Specifications: "Celite shall be used in all concrete in the proportions set forth below for the different concrete mixtures.

........:........:........ Concrete................pounds per bag of cement
........:........:........ Concrete................pounds per bag of cement

"The Celite may be measured by a pre-determined volume in such a manner as will insure the correct proportion by weight, and shall be added at the mixer with the dry materials.

"Only sufficient water shall be used to give a workable consistency and in no case shall more water be added than will give a slump of............inches."

Asphalt Paving Mixes: The use of Celite in place of finely divided fillers, such as limestone dust or portland cement, or in combination with limestone dust in the proper percentage, greatly improves the stability of the mix. Detailed information gladly furnished on request.

THE PHILIP CAREY COMPANY

Lockland, Cincinnati, Ohio

Special Asphaltic Compounds and Compositions

BRANCHES, DISTRIBUTORS AND DEALERS IN PRINCIPAL CITIES

Products: ELASTITE EXPANSION JOINT, ELASTITE BRIDGE FLOORING, ELASTITE TRACK INSULATION, ELASTITE PREFORMED TRACK PAVEMENT.

Elastite Expansion Joint is used in concrete roads and streets and in other monolithic concrete construction to prevent damage to the work due to expansion and contraction. It is composed of two substantial sheets of asphalt saturated felt between which is "sandwiched" under pressure a heavy body of special asphaltic compound.

Elastite Expansion Joint is stiff and strong and keeps its shape in any weather. Easy to use, free from breakage and loss, economical in service. It is relied upon by the Road Building Industry and has been used for years in important work all over the world.

Elastite Expansion Joint is made in a variety of thicknesses, in any width up to 36 inches. Lengths 5 feet to 10 feet are standard, but longer pieces can be supplied, limited only by convenience in handling.

Table below shows standard sizes and corresponding net weights. These weights are averages for estimating purposes only and are not guaranteed. Add 20 per cent to cover weight of crates, except of course, in the case of carloads for bulk shipment.

We will gladly supply you with samples, weights, prices and descriptive literature.

AVERAGE NET WEIGHTS PER 100 LINEAL FEET

	Thicknesses				
Widths	¼″	⅜″	½″	¾″	1″
3 ″	36 lbs.	51 lbs.	68 lbs.	105 lbs.	143 lbs.
3½″	42 lbs.	60 lbs.	79 lbs.	123 lbs.	167 lbs.
4 ″	47 lbs.	68 lbs.	90 lbs.	140 lbs.	190 lbs.
5 ″	60 lbs.	85 lbs.	113 lbs.	175 lbs.	238 lbs.
6 ″	71 lbs.	102 lbs.	135 lbs.	210 lbs.	285 lbs.
7 ″	83 lbs.	119 lbs.	158 lbs.	245 lbs.	333 lbs.
8 ″	95 lbs.	136 lbs.	180 lbs.	280 lbs.	380 lbs.
9 ″	106 lbs.	153 lbs.	203 lbs.	315 lbs.	428 lbs.
10 ″	118 lbs.	170 lbs.	225 lbs.	350 lbs.	475 lbs.
11 ″	131 lbs.	187 lbs.	248 lbs.	385 lbs.	523 lbs.
12 ″	142 lbs.	204 lbs.	270 lbs.	420 lbs.	570 lbs.

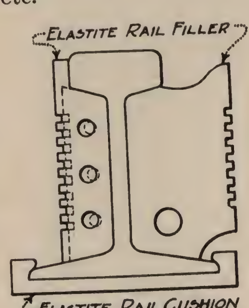
Elastite Track Insulation consists of sections of Rail Filler and rail cushion, composed of a mixture of carefully tempered asphalt and fibre, preformed under heavy pressure to fit the web or base of the particular rail with which it is to be used. It serves as a resilient cushion between the pavement and rail, forming a water-tight seal between them, absorbing rail vibration, dissipating traffic impact, and materially reducing traffic noises.

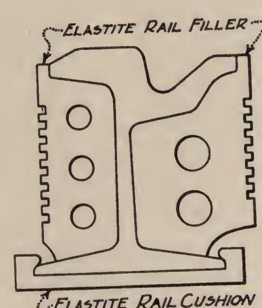
Elastite Track Insulation can be used with any type of track or pavement construction. With both rigid and resilient track, it cushions the track structure and makes it a separate unit from the pavement.

The standard lengths of Rail Filler sections are three feet, although any length up to six feet can be furnished. They can be quickly cut, if necessary, with a hatchet to fit around tie rods, rail braces, welded joints, etc. Special sections of proper shape, length and boring are furnished to insulate any type of splice bar.

Elastite Track Insulation is easily handled and easy to install. It is driven into place by a few blows from a mallet or hammer. It can be installed under any weather conditions by common labor using only ordinary tools.

Years of use on numerous heavily traveled city streets have proven the value of Elastite Track Insulation. At the present time it is giving very satisfactory service in approximately one hundred and fifty different cities throughout the United States and Canada. Among these are Cincinnati, Atlanta, Bangor, Salt Lake City, Winnipeg, Boston, Rochester, Nashville, New Orleans, etc.





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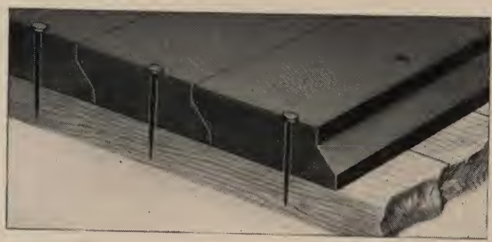
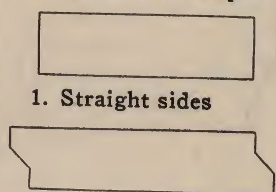


Over wood floors, Carey Elastite Bridge Flooring is simply surface nailed to the sub-floor, nails being spaced 8 inches apart

Elastite Bridge Flooring is a dense, hard, tough composition of asphalt, rag fibre and mineral, formed under heavy pressure into slabs of convenient thicknesses, widths and lengths. It is unlike any other paving material, and when properly laid upon a suitable base will resist the battering and grinding of heavy traffic to an almost unbelievable degree. In years of use none of it has ever worn out. Having no grain and being non-absorptive it does not shrink, swell, warp or check, it is proof against decay.

Two standard shapes



1. Straight sides

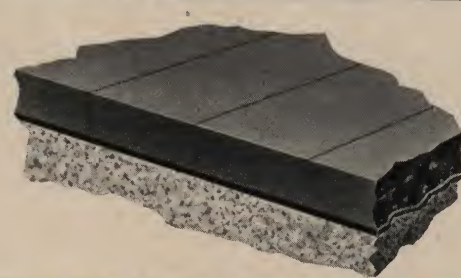
2. Improved ship-lap

Elastite Bridge Flooring does not creep or corrugate. It is not brittle in winter or soft in summer, but remains firm and resilient at all times. It is applied by common labor using ordinary tools.

Elastite Bridge Flooring is a wearing surface only and must be firmly and continuously supported. When applied over a wood deck it is spiked down with ordinary nails, and when laid on concrete it is cemented in place with asphalt.

Elastite Bridge Flooring is made in two standard cross sections, (1) Straight Side, and (2) Modified Ship-Lap, as shown by sketches.

Send for samples, prices and descriptive literature.



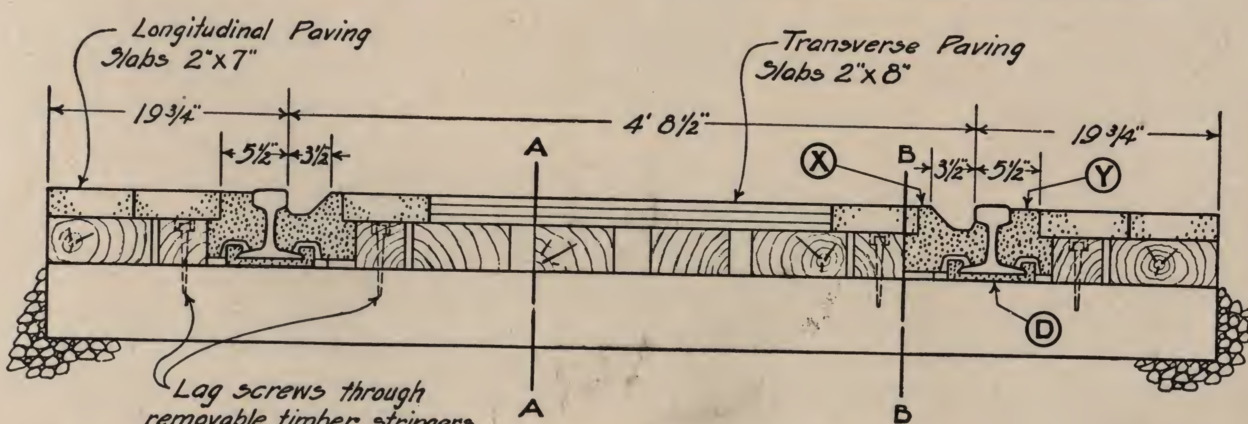
Carey Elastite Bridge Flooring is cemented to a concrete base by applying it in hot asphalt

Elastite Preformed Track Pavement was developed to meet the need for a smooth riding, water-tight and durable method of paving grade crossings and other paved track structures. It consists of special shapes of Elastite Rail Filler designed to be used with preformed pavement slabs in such a manner as to make the crossing an integral part of the track structure. The pavement slabs are similar in composition to the Rail Filler sections, being composed of a mixture containing asphalt, fibre and mineral matter preformed under very heavy pressure.

Elastite Preformed Track Pavement arrives on the job ready for installation. No special tools or machine are needed to lay it, as it can be installed any time by common labor using only ordinary tools such as a hammer, bar, etc.

This material never becomes objectionably soft in warm weather nor does it become brittle at low temperatures. It will not warp nor creep and is capable of withstanding almost any kind of abuse. It has the further special property of knitting and healing together under traffic.

Literature and samples furnished upon request.



COLUMBIA CHEMICAL DIVISION

THE PITTSBURGH PLATE GLASS COMPANY

Barberton, Ohio

Columbia "3-C" 77 to 80% Calcium Chloride

DISTRIBUTORS IN THE FOLLOWING CITIES:

Akron, O.	**Cincinnati, O.**	**Louisville, Ky.**	**Omaha, Neb.**	**St. Louis, Mo.**
Albany, N. Y.	**Cleveland, O.**	**Miami, Fla.**	**Philadelphia, Pa.**	**St. Paul, Minn.**
Atlanta, Ga.	**Columbus, O.**	**Milwaukee, Wis.**	**Pittsburgh, Pa.**	**Toronto, Can.**
Baltimore, Md.	**Dallas, Texas**	**Montreal, Can.**	**Salt Lake City, Utah**	**Trenton, N. J.**
Birmingham, Ala.	**Erie, Pa.**	**New Orleans, La.**	**San Antonio, Texas**	**Warren, Pa.**
Boston, Mass.	**Jacksonville, Fla.**	**New York, N. Y.**	**San Francisco, Cal.**	**Wilmington, Del.**
Buffalo, N. Y.	**Kansas City, Mo.**	**Norfolk, Va.**	**Savannah, Ga.**	**Winston-Salem, N. C.**
Chicago, Ill.	**Los Angeles, Cal.**	**Norwood, O.**	**Springfield, Mass.**	**Youngstown, O.**

Products: COLUMBIA "3-C" 77 TO 80% CALCIUM CHLORIDE.

TRADE MARK

For Road Maintenance: Columbia "3-C" 77 to 80 per cent Calcium Chloride has the remarkable quality of absorbing twice its own weight in water during the cool of night, and half its weight in water when exposed to the sun. This property makes it the ideal dust preventer. It also binds the road together, safeguarding it against being pounded to pieces by traffic and preventing raveling at the edges.

Best Dust Combatant: Columbia "3-C" Calcium Chloride is a pure, white granular chemical—odorless, clean and sanitary. For these reasons it is far superior to oil for preventing dust and is especially valuable for residential sections, hospital grounds, cemetery drives, tennis courts, etc. But two applications a season are necessary to keep a road dustless.

Easily Applied: The application of Columbia "3-C" Calcium Chloride is easily and quickly made, at surprisingly low cost, by equipping a truck with a spreader box. This method is advised for streets, roads and other extensive areas. Two men with a truck can apply "3-C" Calcium Chloride to more than 10 miles of road—over 58,000 sq. yds. in one day. For smaller areas a handy sifter for use with a wheelbarrow or hand truck is satisfactory.

For Curing Concrete Road: Leading highway authorities agree that Calcium Chloride is a real necessity in quickly and economically building concrete roads. Columbia "3-C" Calcium Chloride cures concrete quickly, regardless of season or climate. It makes it possible to open new roads to traffic in half the usual time.

Quick Results: Columbia "3-C" Calcium Chloride is spread uniformly over the surface of fresh concrete as soon as it has set sufficiently (6 to 8 hours) to prevent marring. 2½ lbs. to the square yard is sufficient. It immediately begins absorbing moisture from the air. A single application will keep the pavement wet 24 hours a day as long as it lasts. Its work, however, is practically completed in two or three hours. In that time the concrete absorbs enough to effect approximately a 100 per cent cure.

Containers: Columbia "3-C" Calcium Chloride is manufactured in granulated and flaked form. It is shipped in air tight steel drums of approximately 350 lbs. capacity, or in 100-lb. specially prepared waterproof cloth bags.

Literature: Literature fully explaining the uses of Columbia "3-C" Calcium Chloride will be gladly sent on request.

The Plant Behind the Product at Barberton, Ohio

THE DOW CHEMICAL COMPANY

162 Water St., Midland, Michigan

Dowflake Calcium Chloride

BRANCH SALES OFFICES, New York City, 90 West St.; Saint Louis, Second and Madison Sts.

Products: DOWFLAKE CALCIUM CHLORIDE FOR DUST CONTROL AND CONCRETE CURING.

Dowflake for Road Maintenance and Dust Prevention: Dowflake Calcium Chloride is a clean, white, flaky chemical with the peculiar property of attracting moisture to itself. Through this quality it is able to absorb several times its own weight of water from the air. Applied to the road, Dowflake gives the surface the appearance of a recent rain. It lays the dust, packs the loose top material into a moist, durable layer, lasting several months, and greatly simplifies and reduces the cost of maintenance work.

Dowflake has solved the dust problem on state highways, town and country roads, and is ideally adapted for use in parks, cemeteries, private estates, country clubs, playgrounds, fairgrounds, race tracks and tennis courts. It has stood the test of service in the hands of many of the country's leading highway engineers, and has proven itself practical and economical.

Shipment is made from conveniently located warehouses in either 100-lb. moisture-proof burlap bags or 375-lb. steel drums. It can be applied by shovel, hand spreader, or a standard lime spreader, drawn by a motor truck. The latter method permits treating as much as ten miles of road a day.

Dowflake is immune from caking under ordinary conditions of storage or handling—due to its patented form—thin, superhydrated flakes. It runs freely through the spreader and spreads uniformly.

PATENTED FEBRUARY 17 · 1925
DOWFLAKE
CALCIUM CHLORIDE

Our complete manual, "How to Maintain Roads," contains numerous tables, diagrams, and other features helpful to road men. Write for free copy.

Dowflake for Concrete Curing: Dowflake Calcium Chloride is equally valuable as a curing and accelerating agent. It may be used on the surface, although surface curing has been largely superseded by the admixture method. In either event, it reduces the curing period approximately one-half and eliminates earth or straw covering, ponding, and other old-fashioned and expensive operations.

Admixture curing with Dowflake is quickly and conveniently accomplished by means of a mixer arrangement, as shown at the bottom of this column. The Dowflake solution is mixed in the open mixing tank and pumped up into a storage tank. From the storage tank it passes into a measuring tank, thence into the mixer drum, where it mixes with the gauging water, cement and aggregates.

Addition of Dowflake to the mix accelerates the initial set of the concrete, greatly increases the early strength and gives greater permanent strength. The interior sets as fast as the surface, producing one uniform mass. It leaves no dry spots—no uneven curing, no places to patch the first month because some spots were missed in surface curing.

For those officials and contractors interested in this improved method of concrete curing, we have prepared a free booklet, "How to Cure Concrete." It contains complete information on methods, costs, etc., with numerous diagrams and reference tables. Write for your copy.

THE GRASSELLI CHEMICAL COMPANY

Cleveland, Ohio

BRANCHES AND WAREHOUSES

Albany	Charlotte	Milwaukee	Paterson
Birmingham	Chicago	New Haven	Philadelphia
Boston	Cincinnati	New Orleans	Pittsburgh
Brooklyn	Detroit	New York	St. Louis
			St. Paul

Products: "R-B" Silicate of Soda for Curing, Hardening and Dustproofing Concrete Roads and Floors.

Grasselli

R-B

Silicate of Soda

Grasselli "R-B" Silicate of Soda: Grasselli "R-B" Silicate of Soda is a special grade of Silicate for use on concrete. This grade is a viscuous liquid and weighs approximately 11½ pounds per gallon. It is shipped in tank cars and in 55 gallon steel drums.

Curing Concrete Roads with "R-B": Grasselli Silicate of Soda has been used successfully as a curing agent for many years, and is now specified on state, county and city work. "R-B" Silicate of Soda has no corrosive action on concrete. On the contrary, it improves the wearing qualities by filling the porous concrete surfaces and producing a denser and likewise harder concrete. Approximately one pound of undiluted "R-B" Silicate of Soda is required to cure one square yard of concrete.

One man attends to all the curing. No covering necessary. No sprinkling required. Nothing to remove from the road when it is opened for traffic. This efficient, easy and economical method reduces the curing problem to a minimum.

Grasselli "R-B" Silicate of Soda when applied to green concrete prevents the rapid evaporation of water by filling the pores and sealing the surface, thereby hydrating the cement with the mixing water.

Time of Application: Concrete not protected by burlap should be treated with undiluted "R-B" Silicate as soon as the surface will bear the weight of a man without marking. Concrete properly protected with burlap should be treated not later than ten (10) o'clock A. M. of the day following the placing of the concrete. The "R-B" Silicate in this instance should be diluted with water to a density of between 36° and 37° Be. at 60° F. This mixture should be thoroughly stirred before use to complete a uniform solution.

Application: A number of methods of applying Silicate of Soda have been adopted by different contractors to suit their particular requirements. "R-B" Silicate of Soda can be brushed on with a broom having pliable fibres, or sprayed uniformly over the green surface. It should not be applied during a rain, or if any surface water is present on the concrete. If rain occurs within six (6) hours after such application, the concrete should be recoated with a solution consisting of one (1) part Silicate of Soda and one (1) part of water by volume.

Hardening and Dustproofing Surfaces: Silicate of Soda has been recognized as an economic and efficient hardener for concrete surfaces. The Portland Cement Association, in a booklet on *Concrete Floors*, recommends several applications of a diluted solution of Silicate of Soda as a suitable treatment to improve the wearing qualities of the surface. Test conducted by the United States Bureau of Standards, Washington, D. C., "*Report on Service Tests on Concrete Floor Treatment,*" October 28, 1920, indicates that Silicate of Soda treated concrete surfaces are harder and denser and possess a brighter appearance than the original surfaces.

Booklet on Curing and Hardening: Our booklet, "Curing Concrete Roads, Streets and Bases with GRASSELLI 'R-B' Silicate of Soda," will be mailed free upon request. This booklet gives data and charts showing the results of official tests, and also table giving the amounts of "R-B" needed and the approximate cost per mile for various width roads.

SOLVAY SALES CORPORATION

40 Rector Street, New York

Alkalies and Chemical Products Manufactured by The Solvay Process Company

PLANTS AT

Detroit, Michigan — **Syracuse, New York** — **Hutchinson, Kansas**

BRANCH OFFICES

Boston
Syracuse

Chicago
Indianapolis

Cleveland
Cincinnati

Pittsburgh
Detroit

Philadelphia
Kansas City

Atlanta
St. Louis

Calcium Chloride: Solvay 77-80 per cent Flake Calcium Chloride is a clean, white, flaky material which has the property of attracting and holding moisture. It readily dissolves when exposed because it is able to absorb from the air more than its own weight of water.

The Solvay Process Company pioneered the use of Calcium Chloride for dust laying, the first application being made by them in 1907. Today this company maintains a leading position in the industry. In line with its progressive policy, The Solvay Process Company developed in 1917 the use of Solvay Calcium Chloride for curing concrete and has constantly contributed data and improvements furthering this work.

For Dust Laying: Solvay Calcium Chloride is the "natural dust layer" and an ideal road binder for gravel, dirt, cinder, etc., roads. When applied to road surfaces it becomes incorporated with the top course. It retains enough moisture to lay dust and keep the surface in a smooth, weedless, slightly damp, compact condition. Odorless, harmless, it will not track or stain and has no harmful effect on rubber, varnish or clothing.

It has solved economically the dust problem on state, county and municipal roads and streets. Not only does it eliminate germ-laden dust, but it has also a germicidal action which is highly endorsed by physicians.

For Curing Concrete Roads: Solvay Flake Calcium Chloride is used extensively for curing concrete roads. It accelerates the setting and gives concrete high early strength, which allows roads to be opened to traffic in seven days or less. Two calcium chloride curing methods are in general use. It is either spread on the surface of the green concrete or is added to the mix in solution form. Both methods give far more effective and dependable curing than the old dirt or straw covering, or ponding methods.

Solvay Calcium Chloride curing saves the expense of maintaining detours and eliminates the cost of daily sprinkling, as well as the removal of curing materials.

Patching: The great early strength and greater workability which Solvay Calcium Chloride gives to concrete make it ideal for patching concrete pavements in the minimum of time.

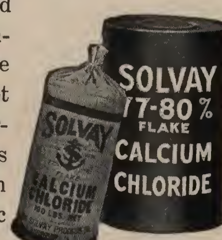
Ice and Snow Removal: Solvay Calcium Chloride is economical to use for removing ice and snow from city streets, bus stops, catchbasins, drains, etc.

Equipment: For using Solvay Calcium Chloride for the various purposes, Solvay Sales Corporation has developed convenient and inexpensive equipment which can be operated by common labor.

Full details will be furnished upon request.

Technical Service and Literature: Special booklets on the subjects of dust-laying, tennis courts, concrete roads, concrete construction, and the Solvay Spreader will be sent free on request. And the advice and assistance of our Technical Service Department are available to assist you with any special problems. There is no charge for this service.

Packages: Solvay Calcium Chloride is shipped in 100-pound moisture-proof bags and non-returnable steel drums containing 375 pounds net. Seventy-five distributing points assure prompt shipment with minimum transportation charges. Carload shipments are traced through to destination by a particularly efficient traffic department.



FLEXIBLE ROAD JOINT MACHINE CO.

Warren, Ohio

Flex-Plane System of Longitudinal and Transverse Joints

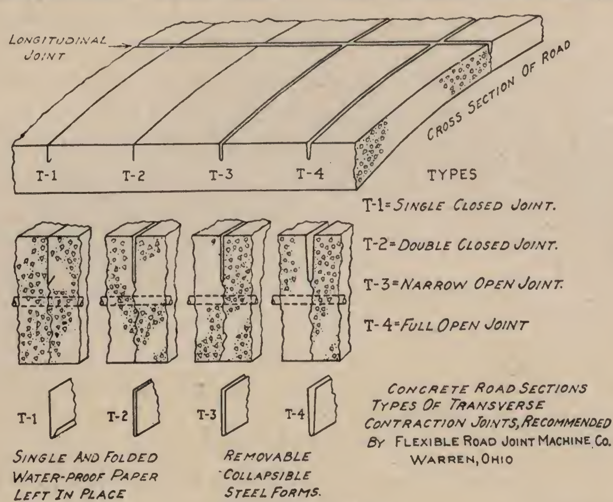
Products: Flex-Plane System of Longitudinal and Transverse Joints.

Description and Advantages of Flex-Plane System of Longitudinal and Transverse Joints: The Flex-Plane System is an improved and more economical method which eliminates the metal center joint and reduces the cost of center joint installation and maintenance.

The Flex-Plane System of Longitudinal Center Joints produces a permanent and effective traffic line in the center of the road, eliminating the expense of painting center lines.

The Flex-Plane System of constructing longitudinal and transverse planes, controls longitudinal and transverse cracks, and is installed at a cost representing a saving to contractors and highway departments.

The Flex-Plane Road Joint Machine is in the form of a 4-wheel bridge which forces a collapsible V-shaped metal plate into the soft concrete behind the finishing machine. The metal plate is expanded by means of a metal wedge strip which locks one joint to another. The machine is then backed up and the floating operations completed with the joint in place.

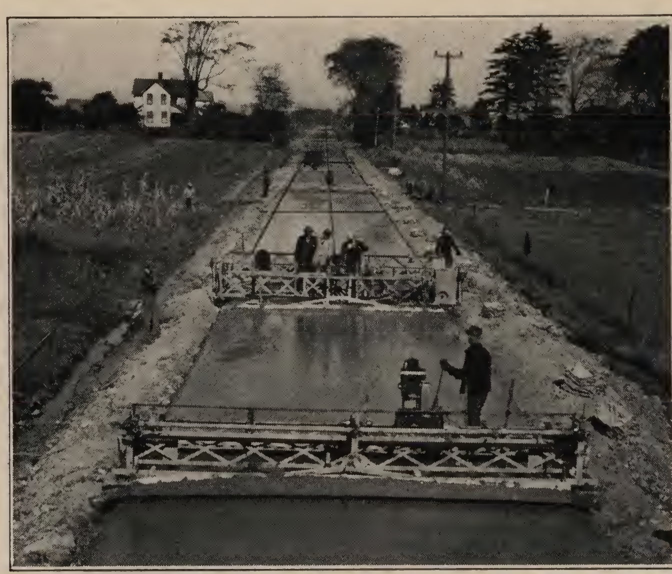


Four Types of Joints

When the concrete has stiffened sufficiently to permit edging, the joint and expanding wedge strip are withdrawn, and may be used over and over again. The double-edging tool is then run over the joint, leaving a groove of required depth and from ¼ to ⅜ in. in width.

It requires two men to install the joint and one man can handle the edging part of the work.

The center joint has been installed at a cost to the contractor of 5 cents per foot. This will vary, depending upon labor costs. Compare this low cost with the cost of steel center plates. It has been demonstrated by roads in service for six years that it was not necessary to spend any money for joint maintenance during that period.



The Flex-Plane System of Longitudinal and Transverse Joints is the most economical for the contractor and the most efficient for the roads. It assures perfect alignment of longitudinal joints mechanically installed with a saving in time and money.

Contractors claim that they can pour 10% more concrete per day when using the Flex-Plane System than when installing metal center joint, because there is nothing under the mixer boom to interfere with operations, or slow down the work.

Highway departments can save not less than $400 per mile by calling for unit prices on center joint. They should call for unit bids on center joint installed with machine and for permanently submerged metal joint.

Comparison of bids to highway departments as observed by us are as follows: metal longitudinal joint, 15c to 25c per linear foot; machine installed joint, 8c to 12c per linear foot.

Types of Joints: Type T-1—This joint is only used as a transverse contraction joint and is formed by placing a strip of heavy waterproof paper around the edge of the installing blade and forcing it into the concrete. After the paper has been forced down until the top edge is approximately one-eighth of an inch below the finished surface of the road, the blade is withdrawn, leaving the paper in place. This joint should be placed at intervals of from 40 to 60 feet, as required.

Type T-2—This is another type of joint used only as a transverse contraction joint and the procedure in installing is the same as noted in T-1, with the exception that the waterproof paper is folded double around the edge of the blade.

Type 3—This is a narrow open joint used for both longitudinal and transverse joints. It is formed by forcing a steel form into the concrete to the required depth. An expanding plate is then forced into this form to hold it in position. After the concrete has set, the expanding plate is removed, enabling the sides of the form to be compressed and pulled out of the concrete. The groove thus formed is then properly edged as specified.

Type T-4—This can also be used as a longitudinal or transverse joint and the method of placing is identical with that of Type T-3, the only difference being that the metal form and the expanding bar are wider, thus forming a V-shaped groove in the concrete.

Bulletin: Send for Bulletin 228.

THE HELTZEL STEEL FORM & IRON CO.

Warren, Ohio

Heltzel Removable Joint Plates for Building Expansion and Contraction Joints

Products: Heltzel Removable Expansion and Contraction Joint Plates for Building Longitudinal and Transverse Joints.

Description: The Heltzel system of center joint construction consists of V-shaped removable joint plates of 10 foot lengths 3 inches deep, ½ inch wide at the top, ¼ inch wide at the bottom with expansion bars and pedestals. The pedestals remain permanently beneath the surface of the concrete.

The joint plates are supported on steel pedestals and held to alignment and grade while the expanding bars are inserted. After the surface has been floated and the concrete takes its initial set, the expanding bar is removed and the V-shaped plate collapsed, withdrawn and used over again.

The joint is finished by a tool which rounds the edges. It is then poured with a suitable filler which seals the joint against surface water and also provides a permanent and distinct traffic line.

The set of joint plates can be used over and over again.

Unsightly Zigzag Cracks Are Prevented: By controlling the breaks through the concrete slab depreciation is thereby effectively reduced.

Installing Heltzel Removable Joint Plates for Expansion and Contraction Joints

Engineering Service: Engineering Department extends complete cooperation to city and road engineers and contractors. With almost twenty years experience in designing paving equipment, we solicit an opportunity of assisting in the construction of better concrete pavements.

Bulletin: Send for Bulletin 200 describing Heltzel modern street and road building equipment.

SERVICISED PRODUCTS CORPORATION

6051 West 65th Street, Chicago, Illinois

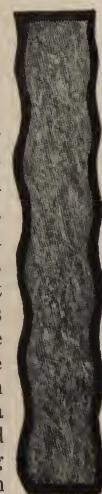
Manufacturers of Expansion Joints and Related Products for Monolithic Construction

Products: Expansion Joints, Gray Filler, Asphalt Filler, Center Strip, Asphalt Primer, Rail Filler, Road Marking Paints, Plastic Cement, Rubber Oil, Bitupack, Waterproofing, Sewer Pipe Compound and Roofing.

Type B expansion joint is a standard premoulded bituminous joint filler which is used in the construction of concrete roads, streets, alleys, courts, driveways, bridges, and similar structures. Its composition of asphalt and fiber is homogeneous throughout and the quantity of the latter is so selected and proportioned as to give the necessary toughness and rigidity without interfering with the compression of the joint in service. The asphalt is refined in a manner which produces a maximum penetration at the desired melting point. This makes it less changeable with the temperature, less brittle in cold weather, and longer lived when exposed to the weather. Carefully controlled processing insures a uniform product which meets all standard specifications.

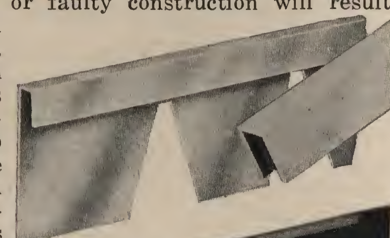
Webbed Expansion Joint is a well recognized alternate for Type B material and is characterized by the felt sides. The handling and installation of the ⅜ and ¼ in. thicknesses is considerably facilitated by the additional rigidity obtained by the side reinforcement, particularly in warm weather. The plastic core is very similar in composition to Type B with the exception that the asphalt content is well over 80% by weight. All physical test results emphasize the additional strength and rigidity which enables Webbed joint to pass all specifications unqualifiedly. The highly resilient fibrated core overcomes disintegration usually caused by traffic and protects the edges of the slabs from spalling.

Type D Expansion Joint is a strictly Servicised product having special properties and being adapted to special construction. It consists of a matted vegetable fiber core which is completely waterproofed and jacketed by a high melting point, ductile asphalt. This construction permits the compression of over 50% of its thickness at a low unit pressure, and without any displacement of the filler at right angles to compression. The combined effect of the compressed core and the adhesion of the jacket to the concrete causes re-expansion when the slabs contract, thus maintaining a water-tight joint. The surface elevations and depressions are of particular value in holding the filler in place when excessive contraction takes place and no support for the joint is provided, such as is often experienced in bridge construction. The more important fields of application include bridges, viaducts, stadiums, sewage disposal plants, concrete conduits, and reservoirs. Wherever oozing is detrimental or even prohibitive, Type D should be specified.

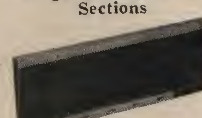


Type D Expansion Joint

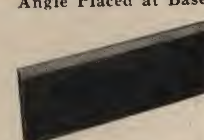
Installation Accessories: Rigid support of bituminous expansion joints is necessary for a satisfactory installation. Abutting ends of sections should be definitely held in alignment or faulty construction will result. The Servicised steel backing plates, channel caps, and reinforcing angles have been developed to help eliminate defective installation which often becomes serious and causes failure. The backing plate is a combined channel cap and backing board which holds the joint in a straight-line vertical position while the concrete is being poured, and can easily be removed, when the latter operation is finished, without disturbing the filler or requiring additional pouring of concrete. Where the ordinary backing board is used, a channel cap placed on the top of the joint insures a straight-line installation and there is no danger of abutting ends getting out of alignment. The reinforcing angles are very efficient in locking two sections of filler together and provide an economical means a common but often overlooked defect.



Angle Uniting Joint Sections



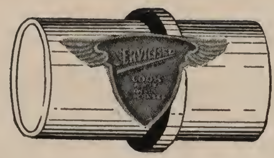
Angle Placed at Base



Angle as Cap Reinforcing

Continued on Next Page

Servicised Sewer Pipe Compound is a mixture of a tough elastic asphalt and a chemically inert mineral filler. At 400° F.



Pouring Sewer Pipe Compound

it pours readily and completely fills the annular space before cooling to a tight flexible joint. Acid and alkaline liquors have no effect on it and cracking due to pipe settlement and root growth through the joint are definitely eliminated. The adhesion to the pipe is positive and a properly poured joint is capable of withstanding pressures approaching the strength of the pipe itself.

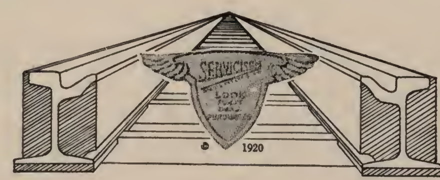
Bitupack, as an alternate for jute and oakum has no equal. It unites readily with the poured compound and does not decay or otherwise deteriorate when in service. The fiber is completely saturated and coated with a soft plastic bitumen which remains flexible at all working temperatures. When calked into place it forms a tight joint and centers the pipe to perfect alignment.

Premoulded Belt Packing: The most rapid, effective, and simple method of effecting a sewer joint involves the use of Servicized Belt Packing. It is a wedge-shaped bituminous strip of the proper size and cross section to completely fill the annular space of the bell when calked.

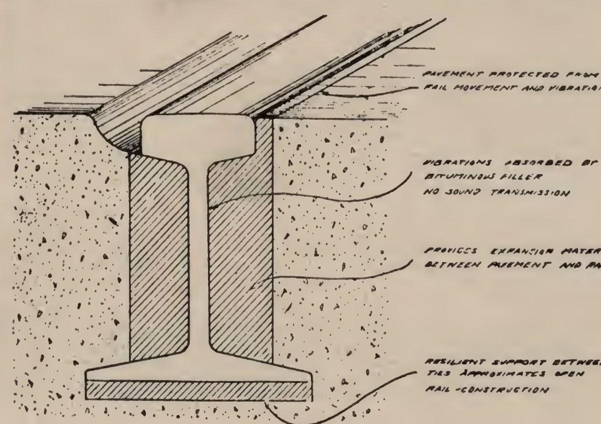
Section of Belt

The specially prepared asphalt which constitutes the major portion of the belt, makes calking easy and positive, and the wedge shape takes care of the pipe irregularities. It is unaffected by sewer liquors, prevents root growth, and can be installed under extremely adverse trench conditions. The rapidity with which these joints are installed avoids all delays in ditching normally caused by slow jointing methods and thus effects an amazing economy seldom considered. Standard belts are made for both clay and concrete pipe in sizes ranging from 4″ to 36″ in diameter.

Calking Upper Belt Section



Rail Filler: Modern bituminous track insulation means sound deadening, waterproofing, shock absorption, and relief from pavement stresses. Sound deadening properties have been incorporated into Servicised rail filler by the use of a partially saturated cellular filler which is completely encased and waterproofed by a resilient asphalt. The asphalt is reinforced by a saturated felt fiber and is present in sufficient quantity to make the moisture absorption of the filler negligible. It is sufficiently elastic to resist the shattering action of the rails and prevents the latter action from being transmitted to the pavement. Much disintegration of a pavement which is in direct contact with the rails is



due to the vibration of the latter caused by the passage of cars. Insulation of Servicised rail filler absorbs these vibrations and thereby reduces maintenance of the pavement adjacent to the rails. Expansion of the rails as well as the pavement produces a relative movement between the two which can readily be absorbed by a bituminous filler, but which, if not absorbed, may cause considerable damage. The expansion of extremely wide pavements creates a lateral pressure against the rails and unless this is taken care of excessive wear of the rails will result from the disalignment produced.

Its extensive use has already established its economy.

Other Servicized Products: Bridge Flooring, Industrial Flooring, Crossing Planks, Insulation Boards.

HOOSIER ASPHALT COMPANY

Alexandria, Indiana

Manufacturers of Expansion Joints

Distributed by Concrete Steel Company, 42 Broadway, New York City

SALES OFFICES AND WAREHOUSES IN PRINCIPAL CITIES

HOOSIER
TRADE MARK

Products: *Pre-Formed Asphalt Expansion Joints.*

History: Organized in 1922, and advocating a new departure in expansion joint construction in the form of an original system of interior reinforcement, this firm has had its product tested and approved in states having rigid specifications such as New York, New Jersey, Pennsylvania, etc.

Hoosier Expansion Joints have been developed through a long series of experiments and are manufactured by mixing with the refined asphalt a sufficient quantity and combination of carefully selected fillers to form a finished product which gives satisfaction to the Engineer and Contractor alike. The presence of this filler gives Hoosier Joints additional tensile strength and cohesiveness. It is of such a nature as not to prevent expansion and contraction of the joint, an important requisite in extreme fluctuations of temperature.

Hoosier Expansion Joints: Have nothing on the sides, such as paper or burlap, to detract from their natural adhesion to concrete. The asphalt adheres to the concrete and moves with the concrete as expansion and contraction occurs. The Hoosier Expansion Joint will not roll over during application nor in use. It is rigid vertically and flexible horizontally. It provides maximum compressibility and resiliency. The accompanying

photograph illustrates this feature. After a severe comparative sun test, a section of Hoosier Joint shows no loss of resiliency, while an ordinary, unreinforced section subjected concurrently to the same test has warped out of all resemblance to its original form.

Analysis: The Asphalt composition in The Hoosier Joint has Melting Point between 234° to 250° Fah.

Specific Gravity at 77° Fah.	1.02
Soluble in Carbon Bisulphide Approx.	99.5%
Penetration at 32° Fah.	21 to 23
Penetration at 77° Fah.	30 to 33
Penetration at 115° Fah.	42 to 46
Susceptibility	2.8 to 3

Report made by Chicago Testing Laboratories, Chicago.

Experience and research work has demonstrated that for the best Expansion Joints, Asphalt of approximately the above characteristics must be used. In order to guarantee a perfect product and a dependable source of supply, the Hoosier Asphalt Company have in their plant equipment for refining and controlling the asphalt used in Hoosier Joints.

Material: The quality and characteristics of the Asphalt used in an Expansion Joint determines to a great extent the degree of satisfaction to be given by the

finished joint. The Hoosier Asphalt Company makes a careful study of the character of the bulk Asphalt used in the manufacture of its products with the idea of securing the best and most suitable specific Asphalt for Expansion Joints.

The Hoosier Expansion Joint needs no foreign material for support. It functions equally well under all the extremes of concrete road and street conditions. It is neither brittle in cold weather, nor soft and bleeding in maximum summer temperatures, because made of a proper mixture of selected fillers and pure bitumen of proper melting point, with specific gravity penetration and other qualities of engineering merit.

Uses: Hoosier Joints are used to take up Expansion and Contraction in all types of concrete construction, such as roads, streets, sidewalks, alleys, gutters, curbs, bridges, floors, dams, roofs, etc.

Sizes: Hoosier Expansion Joints are manufactured in thicknesses ¼, ⅜, ½, ⅝, ¾, ⅞ and 1 inch; in widths 3, 4, 5, 6, 7, 7½, 8, 8½, 9, 10, 11 and 12 inch. Standard length is five feet, although any special length up to twelve feet may be obtained. The Joint can be manufactured cut to crown or special section at a small additional cost.

Shipping Conveniences: To facilitate handling at any temperatures experienced in transit, Hoosier Expansion Joints are especially prepared for freightage and shipped in scientifically designed containers.

W. R. MEADOWS, INC.

Elgin, Illinois

Manufacturers of Sealtight, the Perfected Joint

SEALTIGHT

Product: Sealtight Expansion Joints of Any Thickness and Length for Transverse or Longitudinal Road Installation, Curbs or Bridges, or Wherever Concrete Joints are Needed.

Construction: *Sealtight* is a manufactured premoulded expansion joint made of high grade pure blown petroleum asphalt and a long flexible vegetable fibre filler.

Each ingredient of *Sealtight* was selected after years of experience and investigation had eliminated all but the *right* asphalt and the *right* fibre filler.

The fibre is similar to the kind used in the olden days in the manufacture of rope and is grown under conditions especially suitable for the toughness required in this type of product. A long fibre was selected because it does not break easily and because less of it is required to bind the joint firmly together.

Seals the Joint Perfectly: *Sealtight* is not a joint with reinforced sides—rather it is a homogeneous mass reinforced throughout by a long fibre filler. *Sealtight,* upon oozing, adheres to the sides of the slabs, sealing the joint perfectly. Yet, while *Sealtight* oozes enough to seal the joint, the long flexible fibre prevents the asphalt from "running" out on the road to be carried away by traffic.

Easy to Handle in Any Weather: By selecting the proper asphalt and fibre filler, the manufacturers of *Sealtight* have produced a tough joint which is easily handled in any weather—without having to resort to reinforced sides.

Although the asphalt has a lower melting point than is usual with non-reinforced joints, the long flexible fibre filler gives *Sealtight* plenty of rigidity without brittleness, for summer installation. And, due to the long vegetable fibre filler, as well as to the quality of the asphalt, *Sealtight* does not shatter when handled in cold weather.

Tough—Withstands Rough Usage: *Sealtight* does not break in handling, therefore there is no waste, and an order for sufficient *Sealtight* to complete a job will actually finish it. Will not distort, bend out of shape, nor stick together in hottest weather.

How to Install Sealtight: It is highly important that the expansion joint should be installed perpendicular to the surface of the road, and should extend from the top of the concrete down to the sub-grade. If the joint is not perpendicular, one slab will climb up on its neighbor when expansion takes place. There are three satisfactory methods of supporting the *Sealtight* joint in a perpendicular position while the concrete is being poured: Using a steel or wooden bulkhead or plate header; employing a joint holder; holding it with stakes.

After the concrete has been poured several feet beyond the *Sealtight* joint, the supporting medium is carefully withdrawn without disturbing the joint. The space left by the withdrawal of the header or stakes is filled with concrete and the surface struck off and smoothed with a notched straight edge and split float or a grooved roller.

Sealtight Protected Road

Installing Sealtight

"Make the Road Right—Use Sealtight"

Concrete Road Construction Methods

Concrete road building methods may be thrown into one of two classes: (1) Central or stationary mixing, and (2) Portable mixing.

In central mixing, the concrete mixer is usually located adjacent to a railway siding or a pit or quarry, and the mixed concrete is hauled by trucks or cars.

In portable mixing, the mixer is located on the road and delivers the mixed materials by a chute or a boom and bucket directly into place.

The aggregate (or raw materials) are usually delivered to a portable mixer in one of four ways: (1) By wheelbarrows from piles along the road, usually piles left on the subgrade by trucks; (2) By one-horse dump carts from small stock piles on the side of the road, usually spaced a day's run apart, say 500 ft. apart; (3) By large motor trucks that dump batches of dry aggregates into the skip that feeds the mixer, usually about four batches in four compartments in the truck, or by small (one ton) motor trucks that haul only one batch and dump it into the mixer skip; (4) By industrial railway cars that either dump the materials near the mixer or deliver it in boxes that are lifted by a crane and dumped into the mixer, the latter being more common.

Each of these methods has its economic place, depending upon the size of the job, the length of the haul, the character of the roadway, the grades to be climbed, the location of railway sidings, etc. And among the "etc.," don't forget this: The probability that you will make concrete roadbuilding your main occupation for several successive years.

Why Concrete Roads Cost More Than Concrete Base.—Contractors experienced in laying concrete base for city pavements are apt to underestimate the cost of concrete roads in the country. The following are some of the elements of cost that are usually higher for concrete pavements of this sort than for concrete pavement base:

1. Concrete pavements for roads are richer in cement than concrete base for city pavements.

2. The haul for materials is usually much longer and over worse roads in the country than in the city.

3. Water must usually be piped or hauled longer distances in the country.

4. Two or three times as much water is usually required for concrete road work as for city pavement base, because the subgrade is usually compacted more thoroughly with the aid of water, and water is also used liberally in curing the concrete.

5. The working season is usually shorter in country road work. In the northern states 100 to 125 days actually worked in laying concrete is about the average. In the city most of the haulage of materials is over paved streets, so that rainy weather does not delay work to such an extent as in the country. Materials can usually be obtained from more than one source in a city, thus reducing the number of days lost through lack of materials.

6. Surface finishing, both of the subgrades and of the concrete, is usually more expensive for a concrete pavement than for a concrete base.

7. Labor turnover is usually greater in the country than in the city.

Average Number of Days Worked Per Year.—Excluding Sundays and holidays, a factory keeps its plant busy 300 days per year. But a road building contractor in the northern states is fortunate if he averages annually one-third of 300, or 100 days of actual work for his plant. To begin with, the road building season is only about 7 months long, April 15 to Nov. 15. One-seventh of this time must be deducted for Sundays, leaving 180 days. But rain not only stops work while it is falling, but frequently for days thereafter because of the soggy condition of the earth. Delays in delivery of materials by rail and plant breakdowns cannot be wholly avoided. Also beyond the control of the contractor is the average size of the job and the time of year at which it is awarded to him. If a contractor has a plant that could lay 12 miles of concrete road (18 ft. by 8 in.) per season, but if the average size of contract is 10 miles, obviously his plant must lose time each year because of the relatively small size of the average contract. It is not so obvious, perhaps, but just as fatal to full occupation of his plant if the average size of contract is such as greatly to exceed his season's capacity. Thus, if a 16-mile contract is to be handled with a plant of 12-mile seasonal capacity, there will remain 4 miles to be finished next year. This may so tie up the plant at the beginning of the season as to lead to award of all available contracts to other contractors.

Finally—and probably the most serious of all to the average road contractor—is the award of roadwork to inexperienced competitors at prices that are unprofitable. This occurs so frequently that the road plants of experienced contractors often lie idle an entire season or longer.

TIME LOST IN DELAYS IN HIGHWAY CONSTRUCTION.—H. K. Davis, Chief Inspector of Iowa Highway Commission, had the following article in Roads and Streets:

In the State of Iowa some studies have been undertaken to determine what is average production of the standard types of construction equipment on highway work. On pavement construction the mileage of all types other than concrete has been so small during the two years of study that figures made on these jobs would be of very little value for purposes of comparison. The studies on paving, therefore, were confined to concrete.

The figures here submitted deal with 151 miles of concrete placed in one year and 101 miles laid the next year, not a large program in either year. The merit of the data, therefore, lies not in their mass but in the fact that they were complete and covered average conditions over the area studied, also that they cover all the work done during the two years and not a few particular jobs which might be selected to verify a preconceived theory.

Working Conditions in the First Year.—The season so far as working conditions were concerned was about what could usually be expected:

1. Weather conditions were about what can usually be expected. The spring opened early and work started, but much time was lost immediately by late snows and rains. Mid-summer weather was good, but one extended spell of rain in the fall lost some three weeks of time for all contractors then at work. Winter held off a little later than usual.

2. The labor supply was good and dependable.

3. Shipping facilities were more nearly normal than any time since pre-war days, and caused no delays that are of record.

4. A supply of material adequate to the needs either existed or was developed for the occasion. On only one or two jobs were they delayed for lack of materials to an extent that was noticeable.

5. The work was well distributed over the entire state. Therefore, conclusions drawn from these figures are not limited to a small area where conditions might be very special.

6. The work was well distributed as to size of jobs. No one contractor secured any large block of work in any one location.

The first year the work was carried on—
On 31 contracts,
By 19 contractors,
Using 19 outfits,
On 35 separate sections of road,
In 17 different counties.
The next year the work was carried on—
On 20 contracts,
By 13 contractors,
Using 19 outfits,
On 24 separate sections of road,
In 10 different counties.

The term "outfit" is here used to include all loading, mixing and hauling equipment and their crews which were operated as a single construction unit.

Working Conditions the Second Year.—The working conditions could hardly be called average in certain respects:

The weather was a little better than is usual in Iowa. There being no long, rainy spells. In addition, winter held off for nearly a month longer than can be depended on as a rule, thus enabling several contractors to finish their work when otherwise they would have had to shut down.

In all other respects the conditions were as favorable as the year before, except as regards railway facilities. Because of the coal and shopmen's strikes many outfits were laid up for long periods waiting for delivery of materials when these same were plentiful at the producing plants.

In all respects, except these latter two, the conditions under which these two years' work was done are considered about average for the Middle West, and there may be a lingering suspicion in the minds of some of us that a state of business stagnation caused by labor strikes is coming to be more nearly the normal than the abnormal condition.

Sources of Information.—The figures here summarized were compiled from daily inspection reports sent to the general office of the highway commission by the inspectors on the jobs for each day that the job was under way regardless of whether any work was done. These reports gave the information usually contained in such reports as to feet run per day, cubic yards, cement content, etc., but, in addition, show the amount of lost time and the reason for such delay, from the start to the finish of every job. The information contained in these reports was tabulated by heading a column for each construction outfit with a brief description of the work and the equipment, and following down the column with the feet laid for each day, entering on the same line the reason for any delay that occurred on that day. The runs for a given date show opposite to each other on the same line for the entire state. Delays of less than about 45 minutes are disregarded, they being considered as a part of the day's work and too small to influence materially the day's run. The runs are given in linear feet since in the great majority of cases the pavement is 18 ft. wide and of a uniform depth of 8 in.

Incidentally it may be stated that this method of tabulation has the merit of permitting rapid comparison between all the outfits concerned for any given day or period of time. A state-wide rain shows up plainly on the progress made throughout the entire state on that date. Also it shows up in a rather startling manner the power of recovery of the various outfits after such a rain. Those organizations that are well-known for their pep almost invariably stage a quicker comeback than the easy-going ones. When two outfits work side by side and conditions are similar and the weather the same, and one outfit fails to work more than about half the time, while the other produces steady results day after day, the natural conclusion is that the difference lies in the kind of management brought to the work by the contractor.

Length of Construction Season.—The first year the first concrete laid was on April 8; the last on Nov. 16. This covers an interval of 223 calendar days, which has been taken as the length of the construction season for the most venturesome contractor.

The next year the first concrete was laid on April 27; the last on Nov. 29. This made a construction season for this year of 217 calendar days.

Both of these seasons are considered to have extended a little later into the fall than can regularly be counted upon, though the second season included a greater number of suitable work days than the average.

In the construction season the first year the 29 outfits laid on an average of 27,525 lin. ft. of pavement each, or about 5.25 miles. The second year the 19 outfits averaged 28,021 ft. each, or 5.30 miles.

In fairness to the contractors on the work, it must be stated that this average output for a long season's work is not representative of their producing capacity. This is clearly shown by the fact that several outfits have turned out from 10 to 15 miles in a single season. It is explained by the fact that under existing highway laws Iowa is frequently compelled by the financial situation of the counties to let pavement contracts in units smaller than what would constitute an economical length of run for an outfit for the season.

Average Performances.—The average length of season per outfit required by the contractors the first year to complete their undertakings was 114.3 calendar days, indicating a reduction of nearly 50 per cent from the possible total of 223. As intimated, this reduction is chargeable to the conditions under which the work was let rather than to any unwillingness or inability on the part of the contractors to carry on for a full construction season. The next year the average duration of time on the work was 100.8 calendar days, or considerably more than 50 per cent reduction from the possible 217 calendar days. In any case where a contractor was able to finish his season's work within the construction season it is difficult to see how he can in fairness be charged with the failure to work through an entire season. The findings are reversed when, because of lack of foresight or good management, he fails to make use of all the available time in starting his work in the spring or in running late in the fall, and, as a result, fails to finish.

The first year the average output per outfit per calendar day was 241 lin. ft. This shows how small a figure dar days as a basis for figuring. The second year, however, the average per calendar day was raised to 278 lin. ft.

When Sundays and legal holidays are eliminated from

the total calendar days in the season a more logical basis for comparison results. The first year, with the Sundays and holidays eliminated, there remained 96.1 possible working days on the average. The resulting run figured on this basis was 286 lin. ft. The second year the possible working days averaged 85.7 and the run per day 327.6 lin. ft. These runs reduce to about 600 sq. yds. per possible working day as an average for the two years.

Eliminating all rainy days and other stops of an entire day leaves 74.1 days per outfit on which concrete was actually laid during the season the first year. By the same process the days actually worked during the next season reduces to 61.2, and not all these days were full days, since many of them show only short runs when rain, breakdowns, etc., stopped the work for the remainder of the day. It came as a distinct surprise to most engineers and contractors in Iowa to find that all the concrete pavement laid the first year could have been placed in 2.5 months on straight time, and the entire next season program in two months, if only the numerous delays could have been eliminated. Yet the work occupied the time of all the contractors and all the engineers for most of the year.

The average laid per day worked also seems like a very conservative figure. The first year it was 371.5 lin. ft. The next it rose to 457. This increase is very probably accounted for in part by better management and increased efficiency. But another factor is present which is known to be responsible for the major part of it. This is the increase on the average size of the plant equipment. During the first season the largest outfit on the work was equipped with a 21-E paving mixer, or a plant mixer of equivalent capacity, while there were several smaller than this. The next year there was only one mixer smaller than 21-E and several large outfits came onto the work with mixers as large as a two cubic yard capacity.

The figures here obtained, if conclusive, indicate that 800 sq. yds. of 8 in. concrete is a safe estimate of the daily capacity of a paving outfit on the average, unless the size of mixers is increased, efficiency raised materially, or some method is found of beating the weather.

The 74.1 average of days on which work was done represents 64.8 per cent of the 114.1 average calendar days in the first season. The next the 61.2 average days worked is 60.7 per cent of the 100.8 average calendar days. The writer recalls having asked one contractor's superintendent what in his judgment was the per cent of time a man might safely count on as available in a construction season. After some thought he gave it as his opinion that 80 per cent was the most that anyone could rely on. To verify his statement his outfit the first year came within 1.8 per cent of reaching the 80 per cent he had himself set as a mark. The nearest competitors his firm has had on the Iowa work in two years have not yet passed 74 per cent in days worked out of days spent on the job. Very few have passed 70 per cent and many are around 50.

Classification of Major Delays.—The days not worked were classified under various heads according to the causes for such delay. The per cent of the total calendar days thus lost was as follows:

	Per cent First Year.	Second Year.
Lost on account of Sundays and holidays	14.20	13.67
Lost on account of snow, rain, mud and frost	14.70	9.72
Lost on account of breakdown of equipment	1.09	.47
Lost on account of shortage of material	1.14	9.83
Lost on account of moving equipment	2.56	2.56
Lost on account of all other causes	1.51	3.02
Totals	35.20	39.27

Attention is invited to the fact that a greater proportion of days were lost the second season than the first. Also to the fact that delays due to causes within the control of the men on the job average about the same for the two years.

Those delays least subject to elimination by the contractor are the ones in which the widest variation shows between the two years. For example, the weather was more favorable the second year and contractors lost 4 per cent less of their time from this cause than the first year. On the other hand, the railroad situation the second season caused shortages of material, which delayed the contractors nearly nine times as much as the first season, and caused them to lose 8.7 per cent more of their total days. This quickly consumed all time saved on all other causes and left them behind as much as they otherwise might have been ahead.

Sundays and holidays and weather, as might be expected, make the largest draft on the contractor's available time. Break-downs that cause a whole day's delay are rather noticeable by their absence. Apparently most up-to-date contractors have solved the problem of providing against delays of this sort by having on hand a stock of repair parts and a good live man to see that they are used. Moving and re-erecting of equipment seems to take up a larger amount of time than most of us would suppose.

"All other causes" for days lost include shortage of water, shut-downs to do grading work, shut-down by the engineer or inspector to correct defective work, shortages of labor, strikes, etc. They are each one so small as not to justify separate classification.

The fractional days lost are classified under the same headings as the whole days with the exception of Sundays and holidays.

The figures are as follows:

	Per cent. First Year.	Second Year.
Lost on account of snow, rain, mud and frost	12.41	10.31
Lost on account of breakdown of equipment	5.21	5.24
Lost on account of shortage of material	2.51	3.35
Lost on account of moving equipment	1.58	3.78
Lost on account of all other causes	4.55	6.70
Totals	26.26	29.38

These totals of 26.26 and 29.38 represent the percentage of days worked on which some considerable delay occurred due to some cause or other. The average of actual days was 19.55 the first season and 18 for the next. Subtracting these from days actually worked leaves 54.7 days for the first and 43.2 for the second as the total number of full days worked on the average by all the outfits in the state. On all the other days worked occurred some considerable delay that prevented them getting in a full day.

Individual Records of Contractors.—The low efficiency apparently indicated by many of the figures here given may lead to the thought that the contractors on the Iowa pavement were a small caliber bunch. As evidence that this is not true some of the individual records are here appended. While these in no instance set new marks for the contracting fraternity to shoot at, it is believed that they show that the organizations which have laid the Iowa pavements are well organized and alive to the necessities of their jobs.

One contractor between June 16 and July 30 inclusive, 45 calendar days, worked every day but the 7 Sundays and holidays, or 38 successive working days, laying in that time 20,658 ft. of 18 ft. pavement. This was an average of 543.5 ft. per day or 233½ cu. yds. of concrete.

Another contractor using two separate outfits, worked both outfits every calendar day for 34 successive days from Sept. 21 to Oct. 24, of the first year, laying in this time 29.347 lin. ft. of 20 ft. pavement 8 ins. thick with integral curb and gutter. This was a total of 5.56 miles or an average of 432 lin. ft. per day. Reduced to cubic yards this made 218 cu. yds. per day per outfit. Not the least interesting feature of this run was that a weighted average of the haul shows every ton of this material hauled a trifle over 5 miles. The bulk of it was hauled over a hill road containing seven adverse 6 per cent grades and many smaller ones. A large share of it was hauled up a single grade 9,000 ft. long, a part of which was 6 per cent and which had a number of curves. Practically all the remainder was hauled up a grade a mile long, with several curves and some 6 per cent grades. To complete the difficulties a move was necessary with one of the outfits. By bringing in an extra mixer the remainder of the equipment was moved 15 miles across country and some pavement was laid on the same day.

One contractor using a 21-E paving mixer completed 11 miles of pavement the second season at the rate of 608 ft. for every day he turned a wheel and was at it 64 per cent of the time.

Another contractor finished 16 miles of pavement the second season at the rate of 714.5 ft. for every day worked. He worked 67 per cent of the time and yet made two long moves by rail during the season. This same contractor finished his last job by a continuous run of 20 calendar days at the rate of 920 ft. per day, laying 18,406 ft. of pavement in this time. The working day of this outfit was 10 hours long and this was seldom exceeded by more than a few minutes.

Runs of 1,000 to 1,200 ft. are numerous and 800 ft. was the common thing with many outfits. There can be no debate about the expensiveness of lost time on construction work. The engineering force on the job is there and cannot be used for any other useful purpose as a rule, during the idle times. No increase in the engineering personnel would ordinarily be required if the lost time were eliminated.

Also the contractor in order to continue being a contractor must make a living from his business, and it is impossible to hoodwink ourselves by trying to believe that the cost of his lost time is not charged to the work.

It would seem to be a matter of common interest among all concerned to join forces and do whatever is possible to eliminate waste time. All would profit in the end, the engineer by reputation for efficiency, the contractor by increased output, and the public by reduced costs. Even the machinery manufacturers and material men have an interest, in the increased demand for their products.

These data and conclusions have the very common fault of being destructive rather than constructive. The writer has no solution to offer for the problem presented. In fact, it probably has no single solution. The betterment of the conditions noted will more likely come through the gradual whittling down of the delays at every point by the united effort of all concerned.

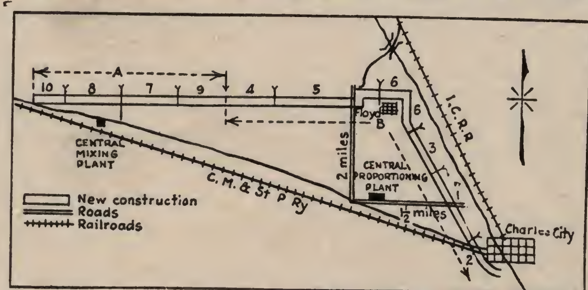
The duty of the engineer in the matter seems clear. It will be his function to point the way, inasmuch as in his hands lie most of the facts and figures, or the opportunity to collect them. In this connection it is the desire of the writer to appeal to others more favorably situated than we are in Iowa, to keep similar records of lost time on highway work. Our program is small and our territory limited while by extending this process to other states soon a valuable mass of data would be on hand.

COMPARISON OF THREE METHODS OF CONCRETE ROAD CONSTRUCTION contains the following:

Opportunity to compare the **wheel barrow method**, the **central proportioning method** and the **central mixing plant method** of concrete road construction was afforded in building 12 miles of road north and west from Charles City, Ia.

The sketch indicates some of the controlling conditions, which were substantially alike for all sections of the road. Two contracts, A and Z, were awarded. Sections 4 and 6 of contract B were constructed by the wheelbarrow method, and sections 1, 2, 3 and 5 by truck haulage of dry batches from a central proportioning plant. All the sections of contract A were construction by wet batch haulage from a central mixing plant.

Statement of Operations.—An 18-ft. pavement, 7 and 8 in. thick, was constructed, using a 1:2:3½ mix on contract B and a 1:2½:1 mix on contract A. On contract B, sections 1, 2 and 3 were concreted in order, using trucks to haul the dry batches to the mixer. With



Sketch Showing Some of Controlling Conditions on Road Job

sections 1-3 completed, a wheelbarrow outfit was started on section 4 and the truck outfit on section 5, both outfits working east. When section 4 was completed, the wheelbarrow outfit was moved to section 6 and worked north and west to meet the paving on section 5. On contract A, the sections were concreted in the order numbered, section 10 being carried over to the next season.

Central Proportioning.—The central proportioning plant has the usual equipment of unloading derrick, overhead bins and cement warehouse. The derrick unloaded into the bins or into stockpiles. Rail deliveries were ample, no delay, practically, resulting from lack of stock at the proportioning plant.

Proportional batches were hauled by 1-ton trucks, with special dump bodies. Work was started with 15 trucks; later 20 trucks were used, and when the haul increased for section 5 west of Floyd, some two-batch, 2-ton trucks were added. These supplementary trucks were not added until the long 3¾ mile average haul was begun, and then the trucks were employed 70 per cent of the time hauling aggregate from Floyd station to the wheelbarrow sections. All of the short haul work was done with the 1-ton trucks.

For dry batch haulage and concreting, the organization consisted of:

5 men with two teams, unloading aggregates.
2 men loading trucks.
5 men handling cement.
25 trucks.
3 men on the mixer.
6 men placing concrete for hand finishing.
1 man finishing.
1 water boy.
2 to 3 fine graders.
2 formsetters.
5 mechanics.
1 pumpman.
1 sprinkling man.
2 men covering the slab.

With this gang, including two foremen, of 64 men, the average output was 400 ft. in 12 hours.

Wheelbarrow Work.—The organization for wheelbarrow construction consisted of:

5 men with two teams unloading aggregates.
3 men handling cement.
3 trucks.
4 men, with two teams and two trucks, hauling cement.
2 men on the mixer.
16 wheelbarrow men.
6 men placing concrete for hand finishing.
1 man finishing.
1 water boy.
2 fine graders.
2 formsetters.
1 pumpman.
1 sprinkler man.
2 men covering.
1 foreman.

The average output was 275 ft. per 11-hour day for this crew of 50 men.

Stockpiling for the wheelbarrow work began fully a month before concreting and continued until the last moment of the operations. In times of stress, the trucks hauling this aggregate, which were normally loaded at the Floyd station, were manned by a night crew using the loading equipment at the central proportioning plant. The cement was sometimes unloaded directly from the cars into the trucks and sometimes it was handled through the central proportioning plant warehouse before being hauled to storage places along the road from which it was hauled by team to the mixer.

Central Mixing.—The central mixing plant consisted of the usual unloading derrick, overhead bins and mixer and cement warehouse. The operating organization was:

5 men unloading sand and gravel.
7 men handling cement.
11 trucks.
2 men, with one team and one tractor, hauling cement.
3 men on the mixer.
3 men placing concrete for machine finishing.
1 finisher.
1 water boy.
4 fine graders, also covering the slab.
2 formsetters.
4 mechanics.
1 pumpman.
1 sprinkler man.
5 men feeding conveyor.
2 foremen.

The output, with 52 men, averaged 250 ft. per 10-hour day.

Shortage of aggregates was a constant trouble in the central mixing plant operation. Since it was realized at the beginning that the gravel supply would be inadequate the proportions of the concrete were changed to 1:2½:1 which approximated more nearly the available material. This change, however, did not make the supply adequate for continuous operation. It also contributed a delay in increased time required to discharge the mixer, because of the high proportion of sand—the time required is the life of the job—and it required about 30 seconds longer than for a 1:1:3½ mixture.

Use of Turntables.—One factor which is not often considered in truck mortality is the practice of using or not using a turntable. Protection of the subgrade by using a turntable was only one of several benefits obtained. Saving in wear and tear on motors was an important gain. It was not uncommon, when the turntable was not used, to see drivers run their engines virtually red hot in struggling to make a turn on a soft or sandy subgrade. The engine depreciation due to many occurrences of this sort soon exceeded the cost of a turntable.

Besides the direct savings by using a turntable there was an evident gain in regularity of truck operations.

It was a tiresome task for a driver to turn a heavy load on an 18-ft. subgrade, particularly if the footing was poor due to soft soil or sand. The difficulty and confusion reduced the morale of the drivers and the whole concreting crew. Two-ton trucks with pneumatic tires, because of their wider tread, did no more damage to subgrade than did the 1-ton trucks. With solid tires the 2-ton trucks were destructive.

Labor Turnover.—Labor turnover furnished an interesting study. It was greatest on the wheelbarrow operations. In two months three entirely new crews were employed. A crew of Mexicans lasted about three weeks and was followed by a crew of negroes which lasted about two weeks. Finally a crew of white men was obtained, but had it not been for the closing of a local factory, it is doubtful if men could have been secured for the wheelbarrow sections to be completed in the allotted time. On the central proportioning plant th greatest turnover was of truck drivers. The central mixing plant drew its labor from the locality and had the smallest turnover as well as more efficient help.

Quality of Labor.—Observation of labor indicates the need of more careful attention to quality where machine operations are largely involved. The heavy turnover of truck drivers has been mentioned. As there was always a waiting list of local town boys wanting to drive trucks this rapid turnover did not on the face of things appear to be a serious factor. The waiting list, however, was made up of "kids looking for a soft job," and as stated by E. B. Gordon, resident engineer:

Floaters do not make good caretakers of cars and on a truck outfit this is one of the most important factors to be considered, both from the standpoint of depreciation of machinery and as it affects the delivery of material. The trucks are the life of the job and they require constant, conscientious care by their driver, which cannot be expected from boys looking for an easy, temporary job. Besides, drivers of this class waste time on the road. Labor is the most important factor in construction performed mostly by machinery. Machinery does the work in road construction with truck haulage from central plants and requires competent help to keep it working efficiently. Many contractors overlook this fact and believe they are saving money by hiring boy operators at low wages, instead of making their machinery more efficient by hiring older, skilled men at wages which will keep them on the work and interested in their machines.

On the dry batch haulage operations truck drivers were getting 40 cts. and 50 cts. an hour or less than the Mexican wheelbarrow men, who were paid 60 cts. an hour. It is, therefore, small wonder that truck mortality was high. This high mortality resulted in delay at the mixer on the long haul, which made at least 15 per cent of the placing outfit's time a total loss to the contractor.

On the wheelbarrow work the high turnover was due not to low wages but to unrest and independence. Labor was scarce and correspondingly careless about holding a job.

Comparison of Methods.—Under the condition observed the yardages per man per hour were: Wheelbarrow, 1.11 sq. yd.; central proportioning, 1.10 sq. yd.; central mixing, 1.31 sq. yd. In comparing the organizations given, the difference between central proportioning and central mixing in number of men required is misleading because the job using dry batch haulage had an adequate amount of material at all times and was able to work a large fleet of trucks, while the job using wet batch haulage was handicapped by a shortage of material throughout the entire season and could, therefore, not employ maximum fleet trucks inasmuch as the daily output was reduced about 50 per cent by lack of materials. Comparing the average daily output of the two outfits, Mr. Gordon states:

I have found that labor proved to be in the same proportion, making labor costs equal and leaving only a matter of personal opinion, between the two methods, as to which is the best to use under varying conditions. Personally, I can see no advantage, one over the other in the matter of cost on a short-haul job, and on a long haul I think either method gets too expensive and the work should be classed as an industrial railroad job. With an

average haul of 3¾ miles on Division B, west of Floyd, the labor cost doubled over the labor cost where the average haul ran from 1½ to 2½ miles, as it did from Floyd to Charles City.

Advantages of Central Mixing and Central Proportioning Over Wheelbarrow Work.—Assuming central proportioning and central mixing to be equal in cost of operation, both exhibited the following advantages over wheelbarrow work:

Reduced demurrage bills on account of being in a position to unload cars onto stockpile immediately after they have been spotted on side track. On wheelbarrow outfits, it is usually desirable to shovel directly from the car, with a result that inclement weather, muddy roads, etc., tie up operations. Then, if unloaded onto the ground, the material has to be handled twice by expensive methods before it is even dumped on the subgrade since an outfit of this kind is seldom equipped with a crane.

Reduction in waste of fine and course aggregate from approximately 10 per cent on wheelbarrow work to about 1½ per cent on truck work. The latter percentage was determined by actual observations on five different concrete jobs last year, all within a radius of 30 miles of Mason City.

A reduction in the number of ordinary laborers required continuously on a wheelbarrow job, a problem worthy of consideration of any country road work requiring any great number of men.

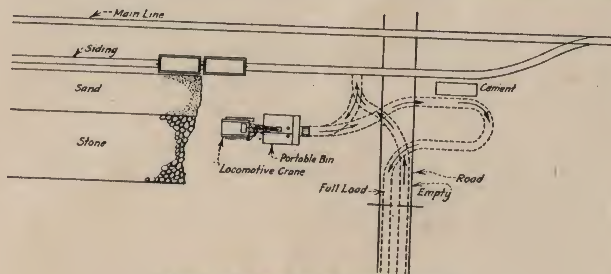
A reduction in the cost of handling all materials For example, on a wheelbarrow job, all material is handled; first, from the car into trucks or wagons and hauled to the paving site to be dumped on the subgrade; second, it has to be handled again by shoveling into wheelbarrow, and in case of bad weather, requires either a third handling at the siding, or demurrage bills, either of which are more or less expensive. These operations are ordinarily performed by hand and are expensive. On the other hand, using the truck outfit, material is handled twice also, but with machinery which greatly reduces the cost.

It is very difficult, in fact nearly impossible, to secure a satisfactory subgrade where the aggregate is dumped on the subgrade. Even though the subgrade has been prepared in first-class shape the trucks hauling material to the job will cut up the grade more or less, and generally more, and after the material has been distributed out ahead of the mixer, it is practically impossible to work a roller in ahead of the mixer to put the grade in the shape it should be. Although trucks cut up the subgrade by the central plant method a roller can still be worked to good advantage and a fairly good subgrade obtained even though it is not perfect.

ECONOMIC HANDLING OF SAND, STONE AND CONCRETE.—By carefully co-ordinating the different parts of the work the Wisconsin Construction Co. of Milwaukee, Wis., was able to make rapid progress in paving the Horicon-Beaver Dam Road on Route 118, in Dodge County, Wisconsin.

Long before the mixer was on the job, two months nearly, the locomotive crane was unloading all the sand and stone that could be obtained. Ten or twelve cars per day were placed in storage until, when the mixer was ready to start, 10,000 yd. of materials were on hand, or sufficient to complete nearly four miles of 18-ft. roadway. At Rolling Prairie, the shipping point, the contractor found a passing track about 1,000 ft. long. The use of this he obtained for handling his aggregate cars. He also obtained the unused portion of the railroad right of way and leased an additional 50 ft. from the land owner next door.

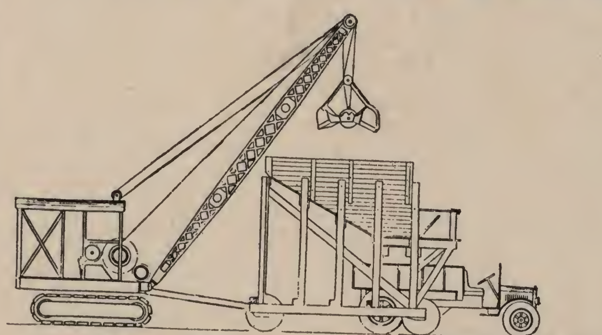
Stocking Stone and Sand.—The crane, which had a 40-ft. boom, unloaded the sand into a pile approximately 20 ft. wide at the base. The stone was unloaded in a parallel pile approximately 50 ft. wide at the base. In laying out the plant it was planned to store more than one-half as much sand per foot of pile as of stone, the reason being that the crane must move longitudinally and must at all times be back of the stone pile. In case an insufficient amount of sand was delivered, the



Layout of Material Handling Plant.

excess allowed leeway before the stone pile was in the way of the crane. In case stone was not delivered and sand was delivered the crane could operate from the sand pile with ease, handling the sand directly from cars to bin and stone from the storage pile to the bin.

Portable Bin.—To make this operation complete a portable bin was necessary. The bin was approximately 14 ft. square and 18 ft. high, made of white oak



Method of Attaching Portable Bin to Crane.

throughout. It was mounted on road wheels, 40 in. in diameter and with a 12-ft. base. Attached by the rigid 10-ft. pole to the crane mounted on multiplanes, it moved forward as the crane moved, thus making unnecessary the peaking of the boom at any time. The bin was supported at three points, the two rear wheels and on the fifth wheel of the front axle. In this way strains due to uneven bearing were reduced to a minimum. Forty yards of aggregate, 15 yd. of sand, and 25 yd. of stone were carried at all times in the bin. Two measuring hoppers were mounted below the bin floor, so designed that they could be adjusted to fit any proportion. Levers, controlled from the platform, operated the upper and lower cut-off gates.

The 2-compartment trucks backed under the bin received 27½ cu. ft. of aggregate in each compartment and ran to the cement shed where they were loaded with 2½ bbl. of cement, the bags being emptied directly on top of the aggregate. The truck hauled the material to the site of the work. Here it turned and backed into the skip of the 21E paver, discharged the load and

moved forward about 2 ft. The skip was then raised, the material charged into the drum of the mixer, the skip lowered and the truck again backed into the skip, discharged the second batch and left for another load.

When mixed, the concrete was discharged into the boom bucket. This bucket was of the spreading type. In other words, the door opened crosswise instead of longitudinally. It consisted of a single leaf, hinged at the back of the bucket which was released by the operator from his platform. The concrete was spread in an even layer as the bucket was drawn back. In case it was desired to push the concrete into a corner of the form, this could readily be done by reversing the motion of the bucket. The door was then used as a plow to spread the concrete into place.

The organization of the crew was as follows:

1 Crane operator.
10 Men cleaning up cars and assisting around plant.
7 Men handling cement at cars and warehouse.
1 Bin operator.
1 Loading foreman.
11 Trucks with drivers.
2 Men dumping trucks.
1 Mixer operator.
6 Finishers.
2 Form setters.
4 Extra men sprinkling and covering pavement.
7 or 8 Men on grade ahead of mixer.

The finishing was done by hand by the use of a strike-off board followed by the roller and belt.

The day following the placing of the concrete it was protected by covering with earth. The success of this operation was shown by the fact that the first mile of 18 ft. highway was built, even with an average round trip haul of between 7 and 8 miles, in 9 working days. This does not mean 9 calendar days, for due to rainy weather it was possible to work only 9 days out of 20. This quantity was placed with a green crew and green truck drivers.

The work was in charge of Mr. P. C. Kwerk, sole owner of the Wisconsin Construction Co., who was assisted by A. G. Brown and Geo. H. Kies.

MATERIAL HANDLING WITH BUCKET LOADER, CRANE AND INDUSTRIAL RAILWAY.—The methods used and results attained in handling materials for the construction of 11.05 miles of concrete road in Palo Alto County, Iowa, are briefly described herewith. The road, which is a Federal Aid project, is located between Emmetsburg and Mallard. The pavement is 18 ft. wide, 8 in. thick at the center and 7 in. at the edges.

Pit run gravel was used in a 1:3:7 mix, which corresponds closely to a 1:2:3½ mix with sand and gravel measured separately. This ratio was determined upon after a careful analysis of the material.

Grading was done in advance by county forces.

The location is on low lands adjacent to the Des Moines River, and at times of high water is partly flooded. The soil is a black loam for the most part underlaid with sand and some sandy gravel. A light industrial railway was installed for the handling of all materials along the road.

Building Up the Stock Pile.—Gravel for the work was mined with a drag-line outfit by the county forces at a point 1¾ miles west and 1 mile south of Emmetsburg, which is at the north end of the project. A delay in the delivery of equipment toward late in the season limited that year's construction to 2 miles of road south of Emmetsburg. Hauling for the first six miles of pavement was in batch boxes over the industrial track direct from the gravel pit to the paver.

During the previous winter gravel was hauled from the pit at the river to form a stock pile at a point six miles south of Emmetsburg. The gravel was loaded into the batch boxes with a bucket loader, equipped with a swivel spout, and was unloaded by a small crane, which raised the batch boxes and dumped them to form a stock pile 250 ft. by 150 ft. by 13 ft. This pile contained approximately 14,000 cu. yd. of material.

Loading Cars with Bucket Loader.—When the next paving season opened the contractors continued to haul gravel from the river stock pile until the midpoint of the job had been passed by the mixer. The loader was then moved to the newly formed stock pile, where tracks and a complete material yard were established; tracks to the river pit were taken up, and the paving operation was continued to the south. Each industrial car carried 44 cu. ft. of material, or enough for 2 batches of concrete. The trains were of 10 cars each. The track was located close beside the finished pavement.

At the stock pile cars were dropped into position by hand, two men doing that work and making the necessary cleanup around the loader. One man operated the loader and one man handled the swivel spout which discharged into the batch boxes. On the average 20 batches were loaded in 20 minutes. The loader was never worked to capacity.

The necessary track moving was done by the loading crew when not busy otherwise and required remarkably little time. These four men with pinch bars moved 100 ft. of track 10 ft. to one side in 10 minutes. As about two weeks were required to run the length of the stock pile, track moving was a very small item.

Handling the Cement.—The loader could reach 20 ft. from the toe of the slope of the pile to the center of the batch boxes. Cement was hauled from Emmetsburg by two small trucks with trailers, each truck and trailer carrying about 100 sacks per trip, and averaging about 10 trips per day. This haul of six miles was over the finished section of concrete road, the grades of which were very flat. A small cement storage shed with a capacity of 250 bbl. was built at the side of the pavement at the material yard, and when cement was not being loaded directly from the trucks to the small flat cars on the industrial track it was stored there. Two flat cars with 60 sacks of cement were in each train, the cement ahead of the locomotive and the batches of gravel behind it.

At the mixer the cement was transferred to small flat cars carried on light 24-in. gauge track laid on the subgrade between forms. As the mixer advanced sections of the track were moved forward and the cement on these small cars was always handy and off the ground. The batches of gravel were dumped in the mixer skip by the familiar type of batch transfer. Cement was put into the skip by hand. The mixer was a No. 21E steam paver with a boom and bucket discharge.

On the long haul of 6 miles four locomotives were used, making four trips each in a 10-hour day. Each batch contained 6 bags of cement and 22 cu. ft. of gravel, which was sufficient to build 1.83 lin. ft. of pavement. An average of 546 lin. ft. per 10-hr. day was maintained on this job. This required 232 cu. yd. of concrete and averaged 1 batch every 2 minutes and 1 second. The maximum pour in 10 hours was 673 lin. ft., or 285 cu. yd., which means that 1 batch was poured every 1 minute and 38 seconds.

The Organization.—A crew of 21 men handled the loading and hauling of material as follows:

3 cement car unloaders.
2 cement truck drivers.
1 material yard foreman.
1 loader operator.
1 loader spout man.

2 men switching cars and cleaning up.
2 men loading cement at shed.
4 locomotive engineers.
4 locomotive firemen.
1 truckman.

21 Total.

A crew of 27 men handled the mixing, placing, etc., as follows:

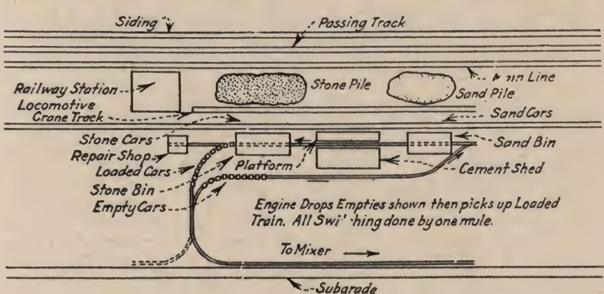
1 steam pump man.
1 man sprinkling.
3 men covering concrete.
1 man finishing edges.
1 machine tamper operator.
2 men spreading wet concrete.
1 mixer engineer.
1 mixer fireman.
1 batch transfer derrick man.
2 men charging cement.
1 man cutting sacks, etc.
2 men handling bail and batch boxes.
2 men on forms.
7 men fine grading.
1 roller man.

27 Total.

CENTRAL PROPORTIONING PLANT ON IOWA JOB.—George W. Zenor gave the following in *Roads and Streets:*

Guided by 10 years of paving experience, the Empire Construction Co. of Des Moines, Ia., developed its most efficient plant layout and crew organization during the 1922 construction season.

Their contract that season was for 11½ miles of concrete pavement on the North Iowa Pike, extending from Algona, the county seat of Kossuth County, Iowa, to the east county line. The slab was 18 ft. wide, 8 in. thick and was made of 1:2:3½ concrete. Reinforcement consisted of ½-inch square bars spaced 6 ft. apart transversely and three ½-in. bars longitudinally.



Layout of Proportioning Plant

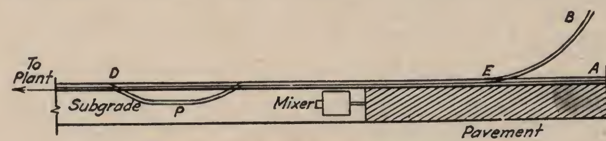
Layout of Central Proportioning Plant.—Grades were moderate; the subgrade was composed of soil which stayed muddy for a long time after a rain; and railway sidings were conveniently located. These conditions favored hauling by industrial railway from a central proportioning plant to the mixer and that was the method selected for handling materials.

The proportioning plant was laid out as shown in the accompanying illustration. The track from the sand bin to the stone bin was given a slope of ½ ft. per 100 ft. which was intended to permit "spotting" by gravity. This slope must be accurately determined, for if it is too steep the cars cannot be stopped, and if too flat they cannot be started. The slope used proved too flat and a mule was required to shift cars at the plant.

Each train was spotted twice—under the sand bin and under the stone bin. Cement was loaded by hand either directly from cars or from the storage shed. With this arrangement a train of eleven cars was loaded in seven minutes. A locomotive crane with a 50-ft. boom and 1½-yd. bucket handled all aggregate from cars to bins.

Switching Arrangement at Mixer.—A plan of the switching arrangement at the mixer is shown in the illustration. By leaving the loaded cars on the uphill side of the mixer one man was able to push them to the mixer crane, thus relieving the locomotives of any waiting. Three 7-ton gasoline locomotives kept the mixer supplied. Fifty industrial trucks, 100 batch boxes and six miles of 24-in. track with steel ties, completed the hauling equipment. The average haul was 3½ miles.

The mixer was a 21-E with an attached crane for transferring batches from the cars to the mixer skip. It also had a spreader bucket. The subgrade was trimmed by a subgrade machine, a finishing machine consolidated the concrete and a 1-man belting device gave the final finish. Most of the pavement was cured with an earth covering kept wet by sprinkling, but on 1½ miles calcium chloride was used for curing. The calcium chloride came in 100-lb. sacks and one man covered a day's run of concrete with it in half a day. Then two men put on a thin earth covering which was found necessary to hold the moisture on the slab. These men also removed all forms.



Switching Arrangement at Mixer

Loaded train from plant pulls on passing track "P." Empty train at mixer passes "P" and goes to plant. Loaded train pulls onto E D and waits till cars at mixer are unloaded, then pushes empties onto E B, dropping at mixer 2 or 3 loaded cars which it pulled behind engine, to be used while switching. Shoves loaded cars onto A E, picks up empties on E B, then loaded cars on A E, drops loaded cars on up-grade side of mixer and goes to plant. Loaded cars are pushed to mixer by one man.

The following list shows the number of men employed on the job and their distribution about the various branches. The figures are based on an average for the work period, as are all other figures given on yardage and personnel.

The Organization.—The average crew of 71 men was organized by the Empire Company as follows:

Men—21 About Mixer
4 Curing concrete and removing forms.
2 Finishers.
1 Finishing machine operator.
4 Spreading concrete.
1 Placing reinforcement.
1 Mixer man.
1 Mixer fireman.
1 Shifting cars.
3 Dumping batches into mixer skip.
3 Form setters.
Men—11 Finishing Subgrade
10 Laborers.
1 Rollerman.
Men—14 Hauling.
3 Locomotive drivers.
3 Brakemen.
5 On track maintenance.
Men—13 Proportioning Plant
3 Dumping cement.
2 At aggregate bins.
1 Man and one mule switching cars.
7 Unloading aggregates (two shifts).
Men—11 General
1 Superintendent.
4 Foremen.
1 Timekeeper.
1 Mechanic.
1 Pumpman.
1 Water line maintenance.
2 Water boys.

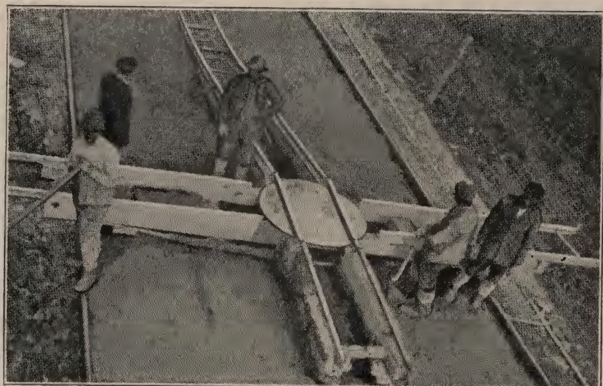
The average run per 10-hour day was 1,220 sq. yds. 8 in. thick, or 267 cu. yds.

CENTRAL MIXING PLANT AND RAILWAY HAULAGE ON MARYLAND ROAD JOB.—A. F. Shure gave the following in *Roads and Streets:*

The job was 4.06 miles in length, and extended from Aiken, a short distance beyond Perryville, nearly to Port Deposit, Md. Both towns are on the beautiful Susquehanna River, which flows through a valley with sides that rapidly rise to a height of 350 ft. The road follows the high ground back from the river.

The concrete was mixed at a central plant and was then hauled to the site of the work in V-shaped cars over an industrial railway. An ingenious raised track system with turntable was utilized in dumping the cars. Although mixing equipment was set up at two points, only the second setup will be described, as there the mixer was at the gravel screening and washing plant.

The Mixing Plant.—At this plant, concrete was mixed in a 21-E paver having a very short discharge chute. A hopper car on wheels holding aggregate for a batch



Turntable for Industrial Railway

was pushed over a track from the sand and pebble bins to the mixer. Cement was stored in a warehouse adjoining the mixer platform and was added at the mixer.

Three 3-ton gasoline locomotives hauled the V-shaped 1-yd. cars out to the work. The maximum haul was 7,000 ft. A train consisted of only four or five cars, each holding one 4-sack batch of 1:1½:3 concrete.

Dumping Arrangement for Cars.—Cars were dumped at the site of the work from a system of tracks mounted on heavy rollers and skids. A flat wedge 3 ft. long was placed on top of each rail in the main line track to form a connection with the inclined rails leading to the elevated system. This inclined section was 16 ft. 10 in. long, and the wedges were hinged to its rails. The inclined track ended at a turntable. From the turntable, tracks led to each side and to the rear. The track at each side was mounted on wooden stringers which were supported by a metal roller 2 ft. 3 in. long and 1 ft. 9 in. in diameter. The track to the rear rested on stringers carried by heavy wooden skids. The turntable was 4 ft. in diameter, and the tracks at the side were 10 ft. 2 in. long. The tops of the rails were about 3 ft. above the subgrade. After the cars were dumped, the dinky pulled the track system ahead as far as desired.

How the Raised Track System Worked.—The elevated track system was designed for a 4-car train, but could have been readily adapted for regular use with five cars by extending the rear track so that a car could be dumped from the turntable without striking the car behind it. It would have been preferable to have all concrete dumped to the rear of the rollers, but when a 5-car train was used it was necessary to dump one car from the inclined section.

With a 4-car train, the dinky pushed up two cars, one of which was placed on the rear track and the other on one side track just inside the form. The two were dumped, and the one on the rear track was transferred to the side track with the other. Next the other two cars were brought up and again one was pushed upon the rear track and the other to the second side track. By dumping to alternate sides of the rear track, and back from the side tracks, a good distribution of the concrete was secured.

On curves, the slab was banked and widened varying amounts. All extra width was placed on the inside. The surface of the pavement was rotated about the center line in securing the superelevation, and the full superelevation had been secured by the time the point of curvature was reached. False forms were set up outside the true forms for use in striking off the transition sections where the change was made from the standard crowned section to the flat, banked surface.

The capacity of the gravel plant was about 150 cu. yd. of washed material in 10 hours, and was limited by the dragline's capacity (1¼ cu. yd.).

Crew Organization.—The organization of the crew was as follows:

Gravel Plant—10 men and foreman.
- 1 Engineer on main hoist.
- 1 Fireman for 2 boilers.
- 1 Signalman.
- 1 Pump man.
- 6 Laborers.

Mixing Concrete—7 men and foreman.
- 2 On hopper car.
- 2 Handling cement.
- 1 Mixer operator.
- 1 Dumping concrete.
- 1 Spotting cars.

Gang on Subgrade—14 men and foreman.
- 2 Form setters.
- 3 Fine grading.
- 1 Pump man.
- 4 Dumping cars.
- 3 Screening and finishing.
- 1 Sprinkling.

Railway Hauling—8 men.
- 6 (Three crews of 2 each).
- 2 Track men (also did odd jobs).

In summer weather, the fine grading crew was increased to six men, who then covered and sprinkled the curing concrete in addition to doing the grading. Probably three men could have been eliminated at the gravel plant had a conveyor been provided for moving the sand from the settling box to the bin.

This road was built by Claiborne Johnston & Co. of Baltimore for the Maryland State Roads Commission, John N. Mackall, Chairman and Chief Engineer. A. F. Shure is District Engineer in this territory for the Commission, and R. Townsend acted as chief inspector. A. F. Ponesmith was the superintendent for the contractor.

COSTS OF FLEX-PLANE SYSTEM OF JOINT CONSTRUCTION.—All joints coming under this classification are installed immediately after the concrete is poured, struck off, and prior to belting or final finishing process.

The president of the Trumbull Engineering Co. of Warren, Ohio, in a letter to us, states as follows:

By the use of a flex-plane joint machine, two men are capable of constructing longitudinal joints for 600 lin. ft. of concrete road in a 10-hour day. They are also

able, within the same period of time and on the same number of lineal feet of work, to install transverse joints at intervals of approximately 50 ft. With this machine they also perform the final screeding and floating operation.

In making a survey I would suggest the following figures: Cost of leased equipment for installing the longitudinal and transverse joints on my latest job, 5 cts. per lin. ft. of joint installed.

Six hundred lin. ft. of longitudinal center joint and 216 lin. ft. of transverse joint totals 816 lin. ft. of joint, i. e., including, as you will notice, both the longitudinal and transverse joints.

Figuring the machine operator's time as 10 hrs. at 60 cts. per hr. and the helper's time as 10 hrs. at 50 cts. per hr. makes a total cost of $11 for installing 816 lin. ft. of both transverse and longitudinal joint.

The next operation is the removal of the collapsible joint plates and the finishing of the joint. One man performs this operation, and at the same time does the necessary edging along the side forms. Figuring this man at 60 cts. per hr. and assuming that half his time is consumed in edging along the side forms and the other half of his time is required for finishing the longitudinal and transverse joints, it would mean that the joint finisher would finish 816 ft. of longitudinal and transverse joint at a cost of $3. Therefore, the total cost of installing and finishing 816 lin. ft. of joint would be $14.

Reducing this to a foot basis, the cost of installation of 816 lin. ft. of longitudinal and transverse joint would be $11 for labor, or 1.72 cts. per lin. ft. of joint. Allowing 5 cts. per lin. ft. for lease of the necessary equipment would make a total cost of 6.72 cts. per lin. ft. of joint constructed. This represents the actual cost, and there is no allowance for overhead or profit.

These prices, of course, would vary depending upon the location. Where labor is cheap the prices would be lower, and where labor is higher they would be increased accordingly.

There has been no allowance made here for the pouring of the joints. Some highway departments take care of the pouring of the joints through their maintenance departments. However, according to my records, these joints can be poured for approximately 1¼ cts. per lin. ft. Therefore, adding this cost of pouring the joints, it would make a total cost of the completed joint in a road ready to be opened to traffic of 7.97 cts. per lin, ft. of joint.

More Costs.—The following figures were sent to us by letter from Mr. H. G. Sours, County Engineer, Summit County, Ohio:

We have built two jobs using this type; one of them with the center line joint only and the other with the center line and transverse joints. A machine was used on both jobs.

It is my understanding that these machines are leased to the contractor on the basis of 5 cts. per sq. yd. for both longitudinal and transverse joints on an 18-ft. pavement; the contractor, however, must operate the machine. It requires two men to install the joint and there have been two finishers behind the machine. The finishers, however, not only pull the joint and edge it, but also do the edging along the form and the straight edging of the surface and whatever hand work is required, so that it could be safely figured that one finisher could handle the edging part of the work. On a basis of 500 lin. ft. of pavement per day, which could be done nicely under good weather conditions, the actual cost of installing the joint would be approximately 1.7 cts. per sq. yd., or a total of 6.7 cts. for the installation of both longitudinal and transverse joints.

The Pope Construction Company of Jefferson City, Mo., states:

There was a saving to us of about $100 per mile by using this machine. Two extra men will do the work and thereby save the metal center joint, costing about 7 cts. per ft.

USE OF BINS IN HIGHWAY CONSTRUCTION.—Employment of bins in the paving construction field has come to the point where it is presupposed that a bin must be one of the items of equipment like a hand shovel. The accompanying diagram shows several different methods of unloading and handling material. Results from each one of them, however, are dependent directly on the flow of sand or stone through bin orifices. That does not necessarily mean that the bins are the governing piece of equipment on a road construction job. They should be subordinated, to and made to dove-tail in with the rest of the equipment to produce a definite yardage of surface per day

The following was taken from Koehring's Handbook on Concrete:

Table I shows the quantity of materials required per hour, day, week and month for three sizes of pavers on a concrete road construction project.

Table II gives the capacity of bins required for a two hours' supply for the paver.

The basis on which these tables have been prepared is an average production of thirty batches per hour for eight working hours, six days per week. It is appreciated that with proper organization this can be pushed up to four hundred batches in a ten-hour day without great difficulty or at the rate of forty batches per hour; yet considering the delays to which such a project is subjected it seems reasonable to adopt thirty batches per hour over an eight-hour day as a basis on which to calculate the quantity of storage space required.

Table I

Minimum Quantity of Storage Required for Economical Operation of Highway Project

Mix 1-1½-3

Machine		Quantity per Hour	Quantity per Day	Quantity per 6 Days	Quantity per 20 Days
	cement	30 bbls.	240 bbls.	1440 bbls.	4800 bbls.
13E	sand	6.66 cu. yd.	53.3 cu. yd.	320 cu. yd.	1066 cu. yd.
	stone	13.33 cu. yd.	106.6 cu. yd.	640 cu. yd.	2132 cu. yd.
	cement	45 bbls.	360 bbls.	2160 bbls.	7200 bbls.
27E	sand	10 cu. yd.	80 cu. yd.	480 cu. yd.	1600 cu. yd.
	stone	20 cu. yd.	160 cu. yd.	960 cu. yd.	3200 cu. yd.
	cement	67.5 bbls.	540 bbls.	2890 bbls.	11800 bbls.
32E	sand	15 cu. yd.	120 cu. yd.	720 cu. yd.	2400 cu. yd.
	stone	30 cu. yd.	240 cu. yd.	1440 cu. yd.	4800 cu. yd.

Table II

Minimum Capacity of Material Bins Based on 2 Hours' Supply for Paver

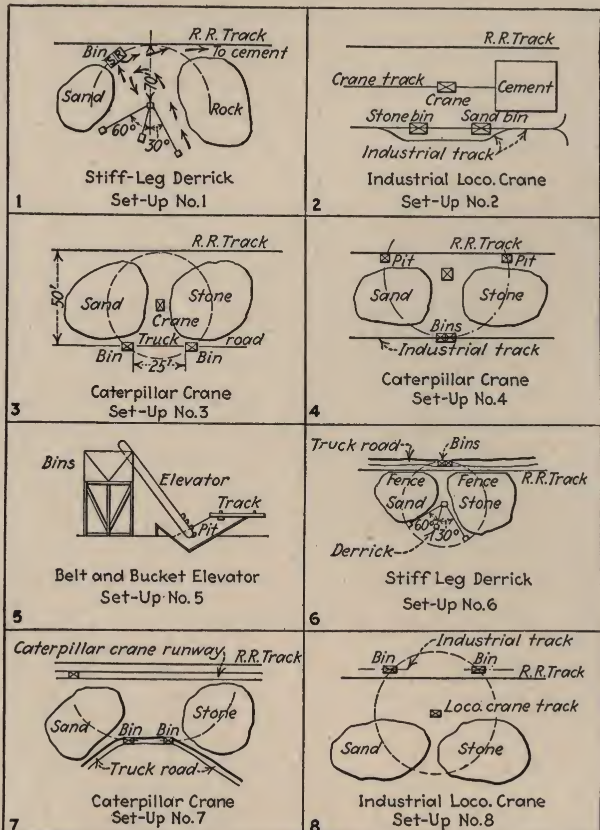
	13E	27E	32E
Sand	13½ cu. yd.	20 cu. yd.	30 cu. yd.
Stone	27 cu. yd.	40 cu. yd.	60 cu. yd.

Bins of the portable type can be mounted either on railroad or road wheels, so that they may move as required by the condition of the storage piles. This moving will seldom actually be done, as under normal conditions material will be handled from cars to bins without rehandling and storing. If the material is used from storage there will be sufficient of it within the reach of the crane to keep the operation going for at least one-half day without changing the location of the bins.

Drag scrapers operated by a light hoist have proved economical for cleaning up the piles when materials are deposited beyond the reach of the crane.

Following was taken from Management and Methods in Concrete Highway Construction by Harrison:

The Batch-Measuring Hopper.—Each charge sent out to the mixer must be measured in some way. Commonly this is done volumetrically, but it may preferably be done by weight. In either case the material must be placed in a large hopper and, by gravity, passed to the measuring device. Speed and accuracy are the essential qualifications of a good measuring device. Volumetric measuring devices can be had which will handle a batch in about 15 seconds. Weighing devices take about 45 seconds. In either case, the time involved is well within the mixer cycle—75 seconds, or 1¼ minutes. Moreover, if the trucks are kept properly spaced, either filling the volumetric measuring device or weighing the batch can be done between the departure of one truck and the arrival of the next; so these devices do not, of necessity, cause single-batch trucks any real delay, and two-batch trucks are delayed only briefly.



Layouts from Contractors' Sketches Show Bins as Fundamental Unit of Handling and Unloading Equipment

The modern hopper is a well-built steel bin, mounted on four steel posts which are long enough to give ample clearance for the trucks. For security against accident the hopper should be set on concrete or other substantial pedestals, and as a matter of practice these should be placed long enough in advance of a move so that they will not interfere with its being completed promptly. Serious accidents have been caused by the failure to erect hoppers on proper footings.

Some of the hoppers are designed so that they can be set up and taken down very rapidly. This is a highly desirable feature as many paving jobs are so long that a number of set-ups must be used. When a shift must be made from one material yard to another, time is an essential element, for a paving crew will not remain long on a job without work, to say nothing of the desirability of avoiding any practice that interferes with the prompt completion of the job. It is not, of course, desirable to sacrifice stability and strength to ease of erection. Rather the thought is that no matter what the stability and strength, a hopper should not be considered adequate unless ease of erection has been considered in its design and in its construction. The size of the parts is of comparatively little importance, as the crane and the trucks can handle pieces of any reasonable size.

The Disadvantages of Home-Made Bins. — Home-made wooden bins should be considered a thing of the past. They are seldom economical even in the matter of direct cost, and when the effect of their generally unsatisfactory operation on truck time is considered, they often prove astonishingly expensive. The home-made bin which is so built that it takes 1 minute to load the gravel and requires the use of another ½ minute to enable the truck to get into position under it requires the use of an extra single-batch truck wherever the rate of production is high. This will cost about $10 a day, a sum sufficient to pay for a good bin in rather a short time! Yet home-made hoppers that cause losses of truck time which are as small as this appear to be the exception rather than a rule.

The Position of the Hoppers.—The position of the hoppers in the yard is an important matter. Indeed, as time is an essential element in obtaining high production it must be saved at every point on the job. For that reason it is an invariable rule that the yard layout should be such that no backing is required. Backing takes both time and space. Moreover, it is hard on the trucks. It is better to spend a little time on planning a yard layout than to waste a good deal of truck time getting equipment through a poorly designed yard. The hopper should always stand far enough forward of the material piles to permit the trucks to drive through. To accomplish this, it may be necessary to hold back the stock piles in some fashion, but this is far less expensive than requiring the trucks to back under the bin from the front for the rather simple reason that it takes less time and offers no excuse for other delays.

OPENING OF CONCRETE PAVEMENTS TO TRAFFIC.—Mr. Edward E. Bauer, instructor in Civil Engineering, University of Illinois, gives the following in *Roads and Streets:*

The transverse bending or beam test is being used more and more to determine the strength of concrete used in concrete pavements. Frequently sample beams are cast while the slab is being poured. The beams are then cured in the same manner as the slab and tested at various ages to determine when the pavement is ready to open to traffic.

What strength should the concrete have before it is ready to be used? This depends upon several factors: (1) the thickness of the slab, (2) the maximum load that is to come on the slab, and (3) whether provision has been made to transfer part of the load across the transverse joints and cracks.

Table I has been prepared based on Older's theory of pavement slab design. This theory may be stated briefly as follows: The pavement slab should be designed for its weakest portion, which occurs at the intersection of a transverse joint or crack and the edge of the

slab or a longitudinal crack or joint. Tests indicate that frequently these corners are off the subgrade so that the slab acts as a cantilever beam. This cantilever beam then can easily be analyzed. The stress at the extreme fibre (the transverse bending stress) is given by the formula

$$S = \frac{3P}{t^2} \qquad \text{(1)}$$

in which:

P equals the load in pounds applied at the corner.

t equals the thickness of the slab in inches.

If steel is included so that half of any load is transferred across any joint or crack, the formula becomes

$$S = \frac{3P}{2t^2} \qquad \text{(2)}$$

In the table values of transverse bending stress are given for thicknesses of slab varying from 5 to 12 in. and for wheel loads of 6,000, 8,000, 10,000 and 12,000 lb., for both free and dowelled corners. No allowance has been made for impact. The stress varies directly as the load and inversely as the square of the thickness. For a given design the stress will increase or decrease as the loads increase or decrease, the stress for a 12,000 lb. wheel load being just twice that of a 6,000 lb. wheel load. For given wheel loads the stresses vary as the square of the thickness, the stress for a 12 in. slab being only one-fourth that of a 6 in. slab. Transferring half the load across a joint or crack is just like cutting the load in two.

Values in excess of 900 lb. are rare at 28 days and should not be counted upon unless test results show values that high. 600 to 700 lb. are average results for the usual 1:2:3 or 1:2:3½ mixes at 28 days. A number of factors affect the rate at which concrete gains strength, such as temperature, richness of mix, quality of cement, and curing methods. Testing is after all the only safe method to determine when a concrete pavement is ready to open and then the design and possible wheel loads must be taken into consideration.

Table I—Values of Transverse Bending Stress (extreme fibre stress) for Various Values of Thickness of Pavement Slab and Load for Both Free and Dowelled Corners

(Computations based on Older's Formula)

Thickness of slab inches	Free Corner None of load transferred across transverse cracks or joints Wheel loads in pounds			
	6,000	8,000	10,000	12,000
5	720	960	1,200	1,440
6	500	665	835	1,000
7	370	490	610	735
8	280	375	470	565
9	220	295	370	445
10	180	240	300	360
12	125	165	210	250

Thickness of slab inches	Dowelled Corner Half of load transferred across transverse cracks or joints Wheel loads in pounds			
	6,000	8,000	10,000	12,000
5	360	480	600	720
6	250	385	420	500
7	185	245	305	370
8	140	190	235	285
9	110	150	185	225
10	90	120	150	180
12	65	85	105	125

Fig.1.—Apparatus Used at the University of Illinois for Making Beam Test

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AGENTS IN ALL THE PRINCIPAL CITIES

Products: Steel Road Forms, Curb and Gutter Forms, Steel Sidewalk Forms, Trailer Agrabatcher Bins.

Also: Finishing Machines, Strikeoffs, Trail Graders, Subgrade Testers, Traveling Bridges, Car Unloaders, Mortar Boards, Tool Boxes, Joint Machines, Batch Boxes, Stationary Bins, Manhole Forms, Sewer Forms, Pipe Forms.

Fig. 1

A New Heltzel Road Form Years Ahead of the Times: Road building conditions of today and of the years to come mean ever increasing problems to be faced by the contractor and the equipment manufacturer. Wider roads, heavier road machines, stricter specifications and keener competition will be the trend.

The new HELTZEL Form anticipates these problems. The time proven HELTZEL design with the double reinforcing flanges at the top and bottom has been further strengthened with a new type of heavy stake pocket and a specially designed lock joint.

The round stakes which are much heavier than those heretofore used, are equally effective in soft or hard ground. The three point contact will hold the form rigidly in position regardless of the bearing on the subgrade. In the course of exhaustive tests to determine the best steel suited for the purpose, these stakes have been driven through a ½" steel plate with a sledge without bending.

The new lock joint is remarkably simple and efficient. By simply driving the sliding porton of the lock, the abutting form sections are brought to true alignment and are wedged tightly against two stakes at the same time. There are no loose parts. When you pick up the form and the stakes, you have everything.

This form is also suitable for integral curb and base and header curb construction. Simplicity and durability are the features embraced in this New HELTZEL Road Form, which insure a form set-up having maximum stability. Write for HELTZEL New Road Form Bulletin.

Fig. 2

Heltzel Steel Plates for Building Longitudinal and Transverse Joints: Collapsible steel contraction joint plates supported on steel pedestals. After the concrete takes its initial set, the expanding bar is removed and the form collapsed and withdrawn without injury to the concrete, leaving an open joint 40% through the slab, which is finished with a special jointing tool and poured with an approved filler sealing the slab and providing a permanent traffic line.

Completely illustrated and described in HELTZEL'S new Bulletin No. 200.

Fig. 3

Heltzel Integral Curb and Base: These forms are used when the curb and base are poured at the same time. The same rails are used as in HELTZEL curb and gutter forms with special overhead hangers which allow clearance for the use of finishing tools. Standard HELTZEL notched angle stakes, clip hangers, and lateral braces assure quick and easy alignment.

These forms are described in detail in HELTZEL'S Catalog of Curb and Gutter, Curb Forms and Sidewalk Forms.

Continued on Next Page

Fig. 4

Heltzel Curb and Gutter Forms: In setting 500 feet of HELTZEL Curb and Gutter Forms, your men handle 16 less rails and 214 less stakes than with other makes of forms. This means time and money saved.

HELTZEL Division Plates can be removed without disturbing side rails and the construction prevents any spreading of the side rails or raising of the face rail. Adjustable stakes with clip hangers permit adjustment to elevation. Adjustable lateral braces permit of quick and easy alignment.

Described in detail in HELTZEL'S Catalog of Curb and Gutter and Sidewalk Forms.

Heltzel Steel Bins and Agrabatchers: Bins—all kinds—Measuring and Weighing Agrabatchers.

Fig. 5

35 and 55 Ton Bins Trailed in One Piece

Fig. 6

80 and 110 Ton Bins Trailed in Two Sections

Heltzel Trailer Bins: HELTZEL Trailer Bins are built in 35, 55, 80 and 110 ton capacity. The 35 and 55 ton bins are shipped, trailed and erected completely assembled. The larger bins come in two sections. Hot riveted construction throughout, reinforced with steel gusset plates at all member intersections. Bridge builders factor of safety. By far the heaviest, strongest and most rigidly constructed bins obtainable. Moved and erected in minutes where other types take hours and days.

Write for HETZEL'S new Catalog of Material Handling Equipment.

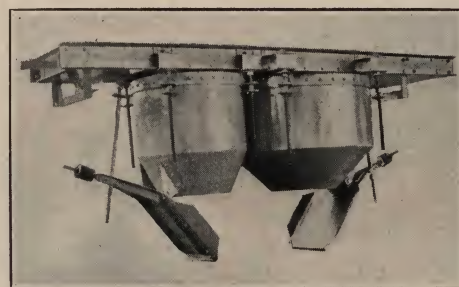


Fig. 7

Heltzel Volume Agrabatchers: Six batches per minute with a single operator. Three types of control, by wheel from the bin platform, by lever from the ground or by chain wheel from the platform or from the ground. A single turn of the wheel or movement of the lever performs the complete operation of filling, cutting off, dumping the batch of sand and stone, closing the lower and opening the upper gate in less than 10 seconds.

For use with wood or steel bins of any make.

Agrabatcher adjusting device supplied on order enables a change of capacities in 30 seconds. The turn of a hand wheel does the work.

Write for HELTZEL'S Material Handling Equipment Catalog.

Heltzel Weighing Agrabatchers: Automatic in operation. Simply set the scale beam permitting the materials to flow into the agrabatchers. When the scale balances, the gate automatically cuts off.

Due to two point suspension agrabatcher will fill and weigh even though bin is not level.

Where specifications require that cement be sandwiched between sand and stone at proportioning plant, HELTZEL automatic weighing agrabatchers cut operation in half.

Described in detail in HELTZEL'S new Catalog of Material Handling Equipment.

METAL FORMS CORPORATION

1436-1440 Booth Street, Milwaukee, Wis.

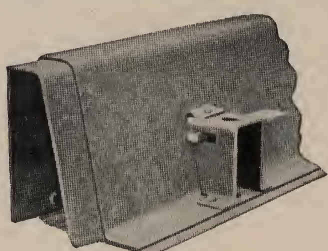
Manufacturers of Interlocking Metal Forms

METAFORMS

Products: "METAL FORMS" ROAD RAILS, INTEGRAL CURB FORMS, CURB AND GUTTER FORMS, CONCRETE MANHOLE FORMS.

Also Metal Forms for Wall Concrete Construction, Silos, Coal Pockets, Etc.

Metaform Road Rails are the solution of the Roadbuilder's "rail" problems. They have been tried and tested and proven to be the greatest single factor in securing better, faster roadbuilding—with surfaces that are true and free from "shallows" that bring "red marks" of the vigilant inspector. They are furnished in 6, 7, 8, 9 and 10-inch in stock—other heights to specifications, and in 10 foot lengths.



Road Rail

Correct design accounts for their solid rigidity—a continuous web of No. 10 gauge steel lapped and riveted, produces their tremendous tubular strength. Top faces positvely resist the battering and weight without denting or crushing. The smooth continuous web design leaves no crevices to catch concrete. **Smooth, Solid Joints:** The long over-lapping joints of these heavy steel rails hold them in place to stay once the stakes have been driven and the wedges hammered home. The tight, smooth joints won't collect the concrete, the inner and top flanges butting snugly upon each other even when the form is set curved. Ample play is provided in the joints for all ordinary curves, the outer edges being permitted to slide just enough to follow the radius.

Showing Solid Joint

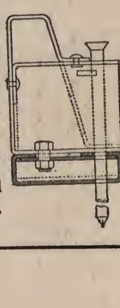
The Back Flange Resists Pounding: The continuous web formation provides the tubular strength that supports the finisher or subgrader. There can be no "springing" or distortion. They provide rigidity for "bridging" over hollows with strength more than sufficient to carry the heavy finishing machines without the slightest tendency to buckle.

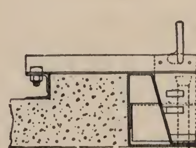
The end plate is of 3/16" steel riveted solidly to the rail, with rounded lower corners forming the male end for joining. The stake boxes are located a few inches of the end of each rail giving doubly firm anchorage to each joint. The wedges cannot get loose as heavy pins in the small ends prevent slipping out of the stake boxes.

For changing the height of Road Rails.

Bolted to bottom of rail at stake boxes.

Manufactured on order only.





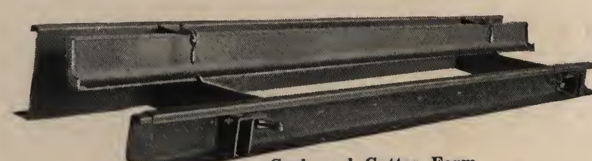
Integral Curb for Bitulithic Surfacing

Back Rails for Curb Work: Metaform rails lend themselves to building on top of each other for back rails in curb work. The simplicity of set-up for this purpose may be taken in at a glance at the illustration shown. The stake wedges and intermediate stakes combine to tie the set-up into a rigid solid form that remains straight and true. The inner face of the back-rail thus formed is as smooth and solid as if a single rail were used.

Metal Curb and Gutter Forms consist of units comprising the following: Ten foot Side Rails made of No. 10 gauge Blue Annealed Steel. Heavy end boxes hold the abutting forms rigidly in alignment. Each rail is provided with 2 Stake Boxes and 2 Pointed Steel Stakes for anchoring. The top of the rails are perfectly smooth and conducive to clean, straightway work and easy screeding and are not weakened by holes or slots being cut at any point in their entire length.

Double Radius Face Rail: This rail is a mighty convenient time saving element—it avoids hand screeding, as it delivers a clean, smooth "rounded top" curb face with the same operations as for a flat top face.

It is made of the same materials as the standard face rails and is further re-enforced, that the original shape may be preserved, by an iron strap riveted to each of the angle-iron ribs.



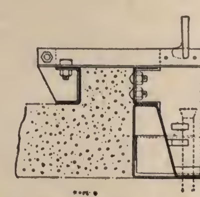
Curb and Gutter Form

Sidewalk Metaforms are basically the same as the curb and gutter forms—the same method of fashioning the elements into forms is followed, using the same simple and effective device for holding the division plates in place and the same stake boxes for anchoring rails.

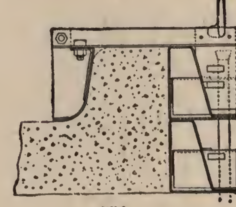
Metaforms provide a sidewalk form which may be easily and quickly set up under the most unfavorable conditions. The stakes permit leveling up the forms regardless of unevenness of depressions in the ground, the wedges in the stake boxes holding them securely up to uniform grade.

The top channel face is perfectly smooth, facilitating that free and effective use of finishing tools which is so essential to speedy and economical sidewalk laying.

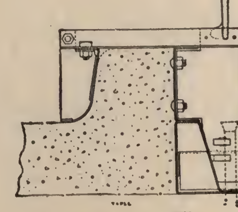
Please write for complete literature descriptive of "Metaforms" for any of the following: Road Rail, Integral Curb and Base, Curb and Gutter, Sidewalk, Building Forms, Manhole Forms, Silo Forms, Coal Pocket and Grain Elevator Forms.



Integral Curb for Brick or Block Surfacing



Integral Curb using two Metaform Standard Rails



Integral Curb with Header Back Rail

BLAW-KNOX COMPANY

621 Farmer's Bank Building, Pittsburgh, Pa.

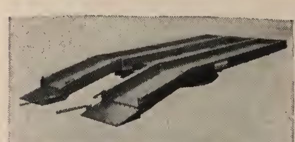
Batcherplants, Road Forms, Clamshell Buckets, Turntables, Inundation System

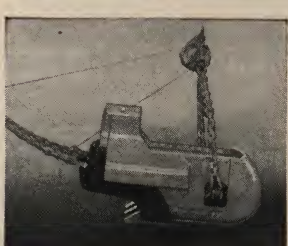
DISTRICT OFFICES:

New York—Canadian Pacific Bldg.
Chicago—Peoples Gas Bldg.
Birmingham—Brown-Marx Bldg.
Buffalo—Genesee Bldg.
San Francisco—411 Matson Bldg.
Detroit—Lincoln Bldg.
Baltimore—Bayard and Warner Sts.
Cleveland—616 Union Bldg.
Philadelphia—Widener Bldg.

Export Division: Milliken Bros.—Blaw Knox Corp., 342 Madison Ave., New York City.

Products: BATCHERPLANTS, ADJUSTABLE MEASURING BATCHERS, STEEL BINS, INUNDATION SYSTEM, TRUCK TURNTABLES, ROAD AND STREET FORMS, CLAMSHELL AND DRAGLINE BUCKETS, STANDARD BUILDINGS, CALCIUM CHLORIDE MACHINE, STEEL GRATING AND OPEN FLOORING, STEEL BATCH BOXES.





Blaw-Knox Batcherplants—for storing and measuring sand and stone. A complete line of self-cleaning bins for all purposes and in any capacity. All steel construction. Equipped with adjustable measuring volume batchers, Weighing Batchers or the Blaw-Knox Inundation System. One man operated plant. Few parts. Easily and cheaply erected and dismantled. Shipped complete with measuring equipment attached.

Blaw-Knox Road Forms—for building smooth roads. Dreadnaught Road Forms made from 3/16-in. steel plate. Make smooth roads. Forms are suspended on stakes and withstand impact of heaviest loads. Patented "lock joint" connection keeps the form true to line and grade. Extremely easy to set and dismantle. Send for complete literature.

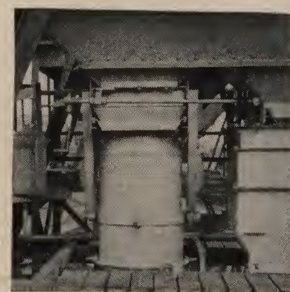
Blaw-Knox Adjustable Measuring Batchers—for accurate measurement of concrete aggregates. All steel batchers for Blaw-Knox Steel Bins or for concrete or wood bins, providing accurate measurement of concrete aggregates by volume or weight. Equipped with roller bearing "no-jam" gate. Blaw-Knox Weighing Batchers are accurate to the pound.

Blaw-Knox Turntables—One man turns loaded trucks of any size.

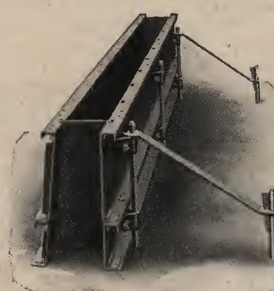
Sizes 1½-ton, 2½-ton and 5-ton capacities. Equipped with demountable wheels for quick transportation if desired.

Blaw-Knox Dragline Buckets—Where the work is tough, the great structural strength and easy digging qualities of the Blaw-Knox Dragline Bucket make it the right tool for the job.

Blaw-Knox Inundation System for Making Constant Concrete—By introducing the correct water-supply into each batch and by compensating for the moisture in ordinary (stock-pile) sand, the Blaw-Knox Inundator makes constant concrete on the job. One man operated! Ask for the Inundation Catalog, describing the Blaw-Knox Inundation System and for information on The Inundation System for Road Construction.



Blaw-Knox Universal Forms—for curbs, curbs and gutters and sidewalks. Steel forms for concrete curb; integral base and curb; combined curb and gutter, and sidewalk construction. Are interchangeable and can be combined for any form of road and street work. Extremely easy to set and dismantle. Send for catalog.



Blaw-Knox Charging Bin-Batcherplants—Portable. A portable self-cleaning outfit of steel Bin and Batchers especially desirable for city paving use, or where bins of small capacities and easy portability are required. Legs are hinged and entire outfit can be transported on truck as a unit. Sizes 13 and 51 tons capacity. Send for complete literature.

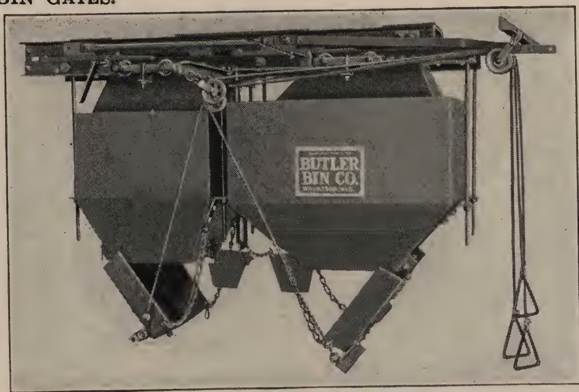
Blaw-Knox Clamshell Buckets—for all kinds of digging and rehandling. Two Line Dreadnaught Lever Arm Type Clamshell Buckets. Pick up heaping loads. Hard digging and fast dumping. Ball-bearing lever arm sheaves up to 1 yd. size. Single Line Buckets for single drum hoists. Attached to and detached from crane or derrick at a moment's notice. A complete range of sizes and styles. Send for Blaw-Knox Bucket catalog.

BUTLER BIN COMPANY

Waukesha, Wis.

Bins and Measuring Hoppers

Products: MEASURING HOPPERS, STEEL STORAGE BINS, BIN GATES.



Type A Measuring Hoppers

Volume Measuring Hoppers: For double and single compartment bins; adjustable for any mix, 4 to 7 bags; smaller size for 1, 2 and 3 bag mix; all steel construction, one man operation; all levers operate from the ground; or by rack and pinion, etc.; accurate measurements; non-jamming shut-off valve.

Type G Weighing Hoppers

Weight Proportioning Hoppers: Arranged for weighing sand and stone separately on one scale or with individual scales for each material. Simple, accurate, easy to install, fool-proof. May be furnished with or without dial reading scale.

Bins for Sand and Gravel Plants: Butler Bins are used extensively in sand and gravel washing and grading plants. Their sturdy construction assures ample strength to support not only the washing and grading equipment, but the wet material as well.

A Typical Semi-Portable Gravel Plant

There's a correct bin for any condition, from the smallest portable plant to large permanent installations.

Ask our engineers to submit their suggestions.

Type V: Two compartment all steel bin built in four sizes: 20, 40, 75 and 110 cu. yd. Can be equipped with volume measuring or weight proportioning Hoppers. Bracing and levers arranged so trucks can pass through in any direction. Self-cleaning hopper bottom type; ships on car by removing four legs and eight knee braces or can be transported on a truck. The 75 and 110 cu. yd. sizes ship in sections knocked down.

Type V—40 cu. yd. Bin

Type S: Single-Compartment Steel Bin, built in five sizes: 15, 27, 42, 75 and 110 cu. yd. capacity. Can be used with cut-off gate or with sand or stone measuring hopper. Easily dismantled by removing four legs and eight braces. Bin compartment ships as one piece on a flat car or can be transported on a truck. The 75 and 110 cu. yd. sizes ship in sections knocked down. The 75 and 110 cu. yd. bins are ideal for material handling yards.

Type S—75 cu. yd. Bin

ERIE STEEL CONSTRUCTION CO.

Erie, Pa., U. S. A.

Manufacturers of Erie AggreMeter Plants and Buckets

The New Type E AggreMeter Plant: The 17 and 22 yard Type E Plants with folding legs are the last word in portability and simplicity. These Plants are shipped with Volume AggreMeters attached. Lift Plant off car or truck, let down hinged legs, put in sixteen bolts, and it is ready for use. It can be quickly handled with crane, or easily set up with truck and handjack.

The 27 and 40 yard Type E Plants are shipped with legs and AggreMeters detached and are quickly erected by simply hoisting bin with crane, then bolting self-supporting legs and AggreMeters in place.

These Plants are particularly desirable on a great variety of concrete jobs on account of their extreme portability. Recommended for street work, building construction, and on road jobs where stock piles of sand and stone are available.

Erie AggreMeters, or measuring devices, are used by contractors, and approved by engineers all over the country. They proportion aggregate by a quick and accurate method which eliminates guesswork and enables contractors to produce uniform concrete at less cost and at greater profit.

AggreMeters are made in both the Volume and Weighing types. Each type is made single or double for the handling of one or two kinds of material. Special Weighing AggreMeters are made for measuring 3 and 4 kinds of material, especially for Central Mixing Plants.

Cement Weighing Hoppers are also made in two sizes for Central Mixing Plants. Their use is becoming quite frequent as equipment for handling bulk cement is becoming perfected.

AggreMeters are made to fit all Erie Bins as well as bins of timber or concrete construction. No special framing is necessary to attach AggreMeters to timber bins, as the single or double AggreMeters come as a unit. Simply bolt AggreMeter under opening, or openings, which should register with the bin gate openings in top of AggreMeter, and it is ready for use.

Erie Buckets: Erie Buckets are of all-steel construction of the power arm type and due to their superior design and rugged construction will stand up under the most severe service. Erie Buckets have maximum closing power and will outdig any other bucket of equal weight. We manufacture both the rehandling and excavating two line buckets in our Peerless and Special Digger types, also a Scraper Type Bucket, and are prepared to furnish special buckets on short notice.

Note the special construction features: Solid cast steel head, hardened guide rollers, wide bearings for pins, rigid corner bar connection, simple rope reeving, all castings of steel, Alemite lubrication, back bands from hinge to hinge, wide lips run to top of scoop, double riveted, and flanged scoops.

The New Type F AggreMeter Plant is the ideal installation for the road or general contractor who requires a large bin capacity for storage of sand and stone; and at the same time a plant that is easily erected and quickly moved. It is a very flexible plant, as it is used for loading compartment trucks, batch boxes on trucks, trailers or industrial cars, or direct into mixer hopper. Furnished in two sizes, 57 and 85 cu. yds.

Erie AggreMeter Plants are made in capacities from 17 to 158 cu. yds. and each Erie Plant is distinguished for its portability, sturdiness, accuracy and speed in operation.

THE FAIRFIELD ENGINEERING CO.

Marion, Ohio

Designers and Builders of Material Handling Equipment

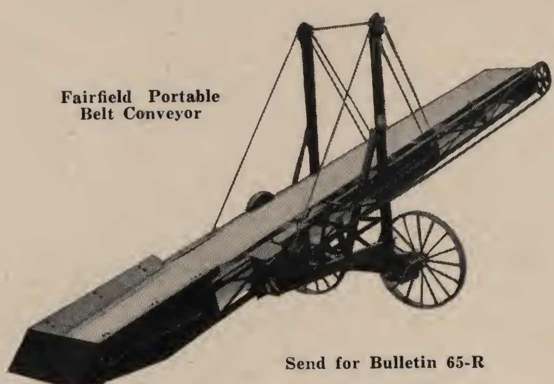
SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

THE FAIRFIELD WAY

Products: PORTABLE BELT CONVEYORS, STATIONARY AND SHUTTLE BELT CONVEYORS, BUCKET ELEVATORS, BELT, APRON AND PLATE FEEDERS, LOADING AND STORAGE BINS —30-50-70 AND 100 TON CAPACITIES, DISCHARGE VALVES AND MEASURING BATCHERS.

The Fairfield Way is to design and build dependable labor-saving machinery for unloading, storing and reloading loose bulk materials under many different conditions.

Fairfield Unloading Equipment Serving Two Fairfield 50-Ton Bins Equipped with Measuring Batchers. Send for Bulletin 60-R



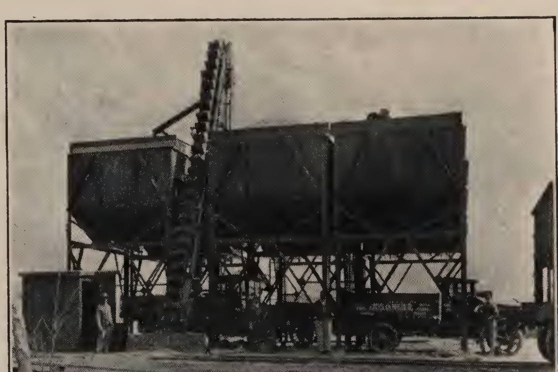
Fairfield Portable Belt Conveyor

Send for Bulletin 65-R

Fairfield Portable Belt Conveyor—Manufactured in lengths from 20 to 60 feet.

Rubber belts—20 in. or 24 in. in width.
Driven by electric motor or gasoline engine.
Three Pulley type troughing idlers with replaceable bronze bushings.
Swiveled carriage wheels.

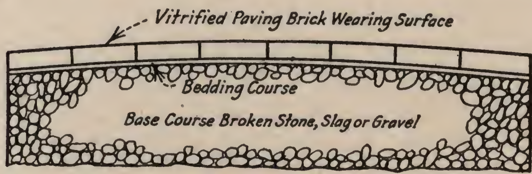
Two Fairfield 50-Ton Bins Served by Clamshell. Send for Bulletin 60-R



Fairfield Unloading and Elevating Machinery with Six Fairfield 70-Ton Storage Bins. Send for Bulletin 60-R

Fairfield Unloading Machinery Serving Four Fairfield 100-Ton Bins. Send for Bulletin 60-R

Brick Pavement



Brick on Broken Stone Base

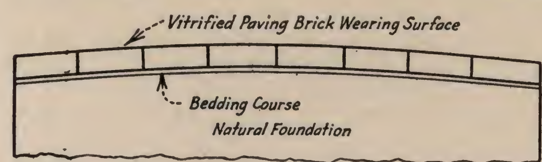
Quantities Per Square Yard

Vitrified Brick—See Table I.

Filler—See Table I.

Bedding Course—Sand, granulated slag, slag or limestone screenings to give average depth ¾-in. (maximum 1-in. minimum ½-in.) after compaction of 15% .... .024 cu. yd.

Base—Broken stone, crushed slag, gravel per inch of depth (after 30% compaction):
- Stone or slag—3-in. to ¼-in. run of crusher coarse aggregate .... .036 cu. yd.
- Screenings—¼-in. to dust—binder .... .007 cu. yd.
- Gravel—100% passing 3-in., 75% passing ¾-in., and 30% passing No. 10 screen .... .036 cu. yd.



Brick on Natural Foundation

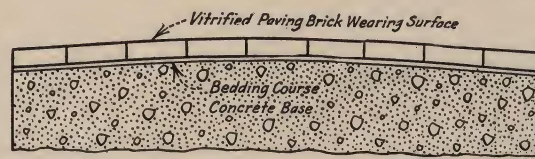
Quantities Per Square Yard

Vitrified Brick—See Table I.

Filler—See Table I.

Bedding Course—Sand, granulated slag, slag or limestone screenings to give average depth ¾-in. (maximum 1-in. minimum ½-in.) after compaction of 15% .... .024 cu. yd.

Foundation—Natural sand or gravel.



Brick on Concrete Base

Quantities Per Square Yard

Vitrified Brick—See Table I.

Filler—See Table I.

Bedding Course—Sand, granulated slag, slag or limestone screenings to give average depth ¾-in. (maximum 1-in. minimum ½-in.) after compaction of 15% .... .024 cu. yd.

Concrete Base—(Per inch of depth) 1:3:6 mix.
- Cement .... .118 sack
- Fine aggregate .... .013 cu. yd.
- Coarse aggregate .... .026 cu. yd.

1:2½:5 mix:
- Cement .... .137 sack
- Fine aggregate .... .012 cu. yd.
- Coarse aggregate .... .025 cu. yd.

TABLE I.—AMOUNTS OF VARIOUS KINDS OF FILLERS REQUIRED FOR JOINTS OF BRICK PAVEMENT

SIZE AND KIND OF BLOCK (Adopted March 28, 1924, by Permanent Committee on Simplification of Variety and Standards for Vitrified Paving Brick of the Department of Commerce of the United States. Subject to Annual Revision.)	LARGE JOINTS (Repressed lug and wire-cut lug brick with ¼-in. lugs; also seconds in stone block; and unusually old brick or block that are relaid.) Amount of various kinds of filler for 1 sq. yd. of pavement				MEDIUM JOINTS (Repressed lug and wire-cut lug brick with ⅛-in. lugs; also stone block with about ½-in. joints.) Amount of various kinds of filler for 1 sq. yd. of pavement				SMALL JOINTS (Plain wire-cut brick without lugs.) Amount of filler for 1 sq. yd. of pavement	
Length—width—depth as usually laid—	Number req'red to lay 1 sq. yd. of pavement	Asphalt filler *Gallon of asphalt	Cement grout filler 1 part cemt. 2 parts sand Sacks of cement	Sand passing No. 12 sieve Cu. yds. of sand	Number req'red to lay 1 sq. yd. of pavement	Asphalt filler *Gallon of asphalt	Cement grout filler 1 part cemt. 2 parts sand Sacks of cement	Sand passing No. 12 sieve Cu. yds. of sand	Number req'red to lay 1 sq. yd. of pavement	Asphalt filler *Gallon of asphalt
8½ x 4 x 3 Plain wire-cut lugless	----	----	----	----	----	----	----	----	36	0.6 (0.9)
8½ x 4 x 3½ Plain wire-cut lugless	----	----	----	----	----	----	----	----	36	0.7 (1.0)
8½ x 3½ x 4 Repressed lug	39	1.9 (2.2)	.10	.010	40	1.5 (1.8)	.08	.008	----	----
8½ x 3½ x 3 Wire-cut lug	39	1.4 (1.7)	.07	.008	40	1.1 (1.4)	.05	.006	----	----
8½ x 3½ x 4 Wire-cut lug	39	1.9 (2.2)	.10	.010	40	1.5 (1.8)	.08	.008	----	----

Sack of cement considered as equalling 1 cu. ft.

*Upper figure is for pouring can method; lower figure for squeegee method.

Brick Pavement Cost Data

Cost of Chipping Tar Off Bricks.—When a brick pavement with tar joints is taken up, the tar must be chipped off the old bricks before re-laying them. This is usually done with a hatchet, after cooling the bricks in a bucket or tub of water. As an average of a good many thousand brick thus cleaned, it was found that one laborer, working deliberately, could be counted upon to clean 60 bricks per hour. With wages at 50 cents per hr., this is equivalent to $8.00 per M for cleaning the bricks.

Cost of Removing and Replacing a Brick Pavement.—Mr. C. D. Barstow gives the following relative to removing a strip of brick pavement 3 ft. wide and 373 ft. long, preparatory to digging a trench. The pavement was laid on a concrete base 7½ ins. thick. The laborers were negroes, and the work was done in a Southern city. The cost was as follows per sq. yd.:

	Cts. per sq. yd.
Removing brick and concrete:	
Laborer, at $0.40 per hour	22
Foreman, at $3.00	3
	25
Re-laying concrete:	
Laborer, at $1.25	25
Re-laying brick:	
Laborer, at $0.40	14
Bricklayers, at $0.75	25
Bricklayers' helpers, $1.75	8
Total re-laying brick	47
Grand total	97

Cost of Constructing New Brick Surface on Old Base.—John C. Hiteshew, Borough Manager of Servickley, Pa., gives the following in *Engineering and Contracting*, Dec. 6, 1922, regarding the taking up of a 31-year-old brick pavement and the laying of a new brick surface on the old hand mixed natural cement base.

The entire job of repaving was done by day labor by the Borough forces. The removing and hauling of the old brick was not charged against the job as it was anticipated the salvage value would pay for this work. A price was set of $2.50 per thousand for the brick on the street in case the purchaser would do the hauling, or $5.00 per thousand if they were delivered. The cost of this part of the work was $413.47 or $.80 per yard, and the Borough received $531.37 for those sold, making an actual profit of $117.90 in addition to approximately 40,000 whole brick that were hauled to the yard for gutters, etc. The bats were either given away or hauled to the dump, and all brick sold and salvaged were entirely whole.

The crown of the street was very irregular and some difficulty was experienced in securing a shapely job. Where uneven places were found in the foundation they were built up either with concrete or tar cold patch. Granulated slag was used for bedding course at a cost of $2.50 per car plus freight.

Brick were hauled from the car, dumped on the street, and then stacked. Two large rope mats were used to dump on, and very little spalling or breaking of the brick was caused by this method. The small percentage chipped or broken were used in filling in the ends of courses, around manholes, etc. A small lawn roller was used to compact the cushion and a 5-ton tandem roller used to roll the brick.

A 300 gal. asphalt kettle was used to heat the asphalt and squeegee pots of 3 gal. capacity used to apply the material. It was found necessary to go over the street with these pots three times in order to properly fill the joints. A thin layer of sand was spread over the pavement after asphalting and allowed to remain about a week, although the street was opened to traffic immediately after the asphalt and sand were applied.

It will be noticed that the cost of truck and team is very low, but these are actual costs of each, figured on a basis of all costs of repairs, feed, parts, tires, etc., but of course do not include the cost of driver, which is figured in the labor costs.

The detailed cost of the improvement was as follows:

	Total.	Per sq. yd.
Hauling Slag for Cushion—		
229 hrs. labor, 30 cts. to 45 cts.	$ 85.60	
63 hrs. truck, 50 cts.	31.50	
30 hrs. team, 25 cts.	7.50	
Total	$ 124.60	$0.0243
Preparing Slag Cushion—		
12 hrs. foreman, 42.7 cts.	$ 5.12	
243 hrs. labor, 35 to 45 cts.	92.95	
Slag	44.02	
Total	$ 142.09	$0.0274
Hauling and Stacking Brick—		
34 hrs. foreman, 42.7 cts.	$ 14.52	
908 hrs. labor, 35 to 50 cts.	326.95	
74 hrs. truck, 50 cts.	37.00	
122.5 hrs. team, 25 cts.	30.62	
Total	$ 409.09	$0.0789
190,000 3-in. Vertical Fibre Block at $25.50 per M., less 3,862 not used	$4,746.52	$0.9160
Laying Brick and Rolling—		
48 hrs. foreman, 42.7 cts.	$ 20.50	
734 hrs. labor, 35 to 50 cts.	271.25	
4½ days roller	99.00	
Total	$ 390.75	$0.0754
Asphalting—		
Hauling asphalt	$ 9.45	
Heating and applying—		
46 hrs. foreman, 42.7 cts.	19.64	
461 hrs. labor, 35 to 45 cts.	166.85	
2 hrs. team, 25 cts.	.50	
83 drums or 5,000 gals. asphalt	473.66	
Asphalt kettle 6 days at $7.50	45.00	
Total	$ 715.10	$0.1380
Miscellaneous Work—		
97 hrs. labor, 35 to 50 cts.	$ 36.50	
7 hrs. truck, 50 cts.	3.50	
13 hrs. team, 25 cts.	3.25	
Sand covering, 474 bu. at 10 cts.	47.40	
Gloves, spikes, thermometers, wear and tear of tools, etc.	42.50	
Total	$ 133.15	$0.0250
Grand total	$6,661.30	$1.2850

Taking Up and Hauling Old Bricks (See Note)—
(Not charged against job.)

	Total.	Per sq. yd.
60 hrs. foreman, 42.7 cts.	$ 25.62	
979 hrs. labor, 35 to 50 cts.	350.10	
55 hrs. truck, 50 cts.	27.50	
41 hrs. team, 25 cts.	10.25	
Total	$ 413.47	$0.0800

Note—

Received for old brick	$531.37
Actual cost of work	413.47
Profit	$117.90

40,000 brick delivered to yard for Borough's own use.

Estimating Cost of Brick Pavement

Cost of Unloading and Hauling Bricks.—Unloading bricks from a gondola car to wagons, each man will average 100 to 130 sq. yds. of brick per 10-hr. day.

In 8 to 10 mins. a gang of 5 men and the driver will easily load a wagon with enough brick to lay 10 sq. yds., which is equivalent to a load of 2 tons. Such a load can be hauled by a team over an ordinary good, level earth street.

In unloading the bricks at the curb line, the driver and another man in the wagon toss brick to two men, who stack them up. They will unload the wagon (14 sq. yds.) in 8 to 10 minutes.

Summing up we have the following cost of loading and unloading (not including the lost team time):

	Per. sq. yd.
0.08 hr. labor loading wagon, at $0.50	$0.04
0.05 hr. labor unloading wagon, at $0.50	0.03
Total	$0.07

Since the lost team time, while loading and unloading,, amounts to about 20 mins. per load, or 2 mins. per sq. yd., we have a cost of 1.3 cents per sq. yd., when team and driver time is worth 80 cents per hr.

A team travels 2½ miles per hr., or 220 ft. per min. Hence the cost of hauling, when the load is 10 sq. yds. or 2 tons, is 6.5 cts. per sq. yd. per mile of distance between the car and the place of unloading.

We have a fixed cost of 7 cts. for labor of loading and unloading, plus 3 cts. for lost team time, or a total fixed cost of 10 cts. per sq. yd. Hence the following rule for the cost of hauling brick by team:

To a fixed cost of 4.2 cts. per sq. yd. add 3.2 cts. per sq. yd. per mile when the load is 2 tons.

By using two extra wagons, one empty wagon at the car being loaded, and one full wagon unloaded at the street, the item of "lost team time" can be almost entirely eliminated, for a team can be unhitched from an empty wagon and hitched to a loaded wagon in 1 min., and by fastening a chain from the rear of the loaded wagon to the tongue of the empty, the empty can be pulled up alongside the car ready for loading. When this is done, the "fixed cost" is reduced to 7 cts. per sq. yd. Then if 3 tons are hauled per load, as is common on city streets, the cost of hauling brick by team becomes:

To a fixed cost of 7 cts. per sq. yd. add 4 cts. per mile of haul.

The use of extra wagons is particularly desirable when a smaller gang than 5 men is engaged in loading, for with a smaller gang the lost team time would be correspondingly greater if there were no extra wagons.

Cost of Laying Bricks.—Bricks are ordinarily carried in wheelbarrows from the piles along the curb and dumped on the finished pavement behind the bricklayers. The average wheelbarrow load is about 40 "pavers," or 270 lbs., and is seldom more than 45 "pavers," or 305 lbs. Such loads are readily wheeled over level runways and even up a short slope of 1 in 7. A man will readily load a barrow in 1¾ mins., at which rate, if he were doing nothing else but load barrows he would average 14,000 "pavers" loaded in 10 hrs. But the men who load the bricks usually wheel them to place and dump them. Where the distance to be wheeled is about 40 ft., it takes about ⅜ min. to go and return plus another ⅜ min. lost in dumping the barrow and in brief rests; so that a day's work is 10,000 "pavers," or 175 sq. yds., loaded and wheeled 40 ft.

Two men wheeling bricks to each bricklayer is a common ratio, and 300 sq. yds, laid per day by a bricklayer is considered a big day's work, although it is frequently exceeded. This would require the wheeling of 150 sq. yds. per man on wheelbarrow.

Foremen are often very careless in spacing the wagon loads of brick along the curb, so that there are frequently too many bricks at one part of the street, and too few at another. When this is so, more men with wheelbarrows are required to deliver the bricks.

The number of men to each bricklayer is ordinarily about as follows:

	Per Hr.
1 bricklayer	$1.00
2 men wheeling and delivering bricks	1.00
1 man spreading sand cushion	.50
1 man ramming	.50
1½ men grouting joints with cement	.75
½ man raising sunken brick, etc.	.25
7 men total	$4.00

When the bricklayer, who really "sets the pace," lays 30 sq. yds. per hour, the cost of laying and grouting is 13 cts. per sq. yd., to which must be added for foreman and water boy, making a total of 14 cents per sq. yd. for laying brick. This is a cost that may be attained under good management, and with skilled men. It is, perhaps, nearer an average, to say that 21 sq. yds. per hour are commonly laid by each bricklayer, making the cost of laying 20 cts. per sq. yd., inclusive of foreman and water boy.

Summary of Cost of Brick Pavement.—Based upon the foregoing data, we may summarize the cost of a brick pavement, bricks laid on edge, grouted with 1 to 1 cement mortar, as follows:

Materials:	
40 brick blocks at $45.00 per M	$1.80
0.042 cu. yd. sand for cushion 1½ ins. thick, at $2.00	.08
0.004 cu. yd. sand for grouting joints, at $2.00	.01
0.028 bbl. cement for grouting joints, at $2.50	.07
Total materials	$1.96
Labor:	
Hauling brick 1 mile (10+7 cts.)	$0.12
Laying brick and grouting	.14
Total labor	$0.26
Total materials and labor	$2.22
1/6 cu. yd. concrete base, at $7.20	1.20
1/3 cu. yd. earth excavation, at $0.60	.20
Grand total	$3.62

The above costs of concrete base and of earth excavation are merely assumed for illustration.

The cost of filing of the joints of a brick pavement is discussed in detail in the next paragraph.

Cost of Filling Joints of Brick Pavement.—To determine the area of brick pavement occupied by the joints, refer to the table below:

Size of Brick.	No. of Brick Per Square Yard With ⅛-in. Joints	No Allowance for Joints
2¼x8x4, laid flatwise	38.7	40.5
2¼x8x4, laid edgewise	67.1	72.0
2¼x8¼x4, laid flatwise	37.5	39.3
2¼x8¼x4, laid edgewise	65.1	69.8
2½x8½x4, laid flatwise	36.4	39.3
2½x8½x4, laid edgewise	57.2	61.0
3¼8½x4, laid flatwise	36.4	38.1
3¼8½x4, laid edgewise	44.5	46.9
3x9x4, laid flatwise	34.4	36.0
3x9x4, laid edgewise	45.5	48.0

It will be noted above, for illustration, that 2½x8½x 4-in. bricks laid on edge require 57.2 bricks per sq. yd. when laid with ⅛-in. joints, or 61 bricks if it were possible to lay them so close that there would be no joints. Hence the joints occupy an area equivalent to 61.0—57.2=3.8 bricks per sq. yd. But 3.8÷61=6.2%, which is the percentage of area occupied by joints. Since the joints are 4 ins. deep, each sq. yd. of pavement contains 6.2%×(4÷36)=0.007 cu. yd. of grout or tar used to fill the joints. Table I on page 134 gives the amounts of material required to fill joints.

Tar has a specific gravity of 1.25, and therefore weighs 78 lbs. per cu. ft., or a trifle more than 10 lbs. per gal.

As above given, the labor of grouting joints of "pavers," including mixing the Portland cement and sand and brooming it into the joints, is less than 3 cts. per sq. yd., where the men work at all vigorously.

The labor cost of melting and pouring tar into joints is usually about 3 cts. per gal., when wages are 50 cts. per hour.

Number and Weight of Paving Brick Per Square Yard.—The so-called "standard brick" for house building is 2¼x8¼x3 ins., and for a time brick for paving purposes were also made of the same dimensions. A few years ago the size of the standard brick for paving purposes became 2½x8½x4 ins., and such bricks are commonly called "pavers." It takes 52 to 57 of these "pavers" per sq. yd. Larger sizes, 3½x8½x3 or 4 ins., are now usually made.

When the sizes are known there is a factor of uncertainty to the inexperienced, and that is the thickness of the grouted or tarred joints between bricks as ordinarily laid. I have found as the average of a large number of measurements that the thickness of the average joint is about ⅛-in., unless the "pavers" are made with projecting lugs to give a wider joint.

If the surface area of a brick is 3½x8½ in. with ⅛-in. joints, there are 40 per square yard.

Having obtained the price per thousand (M) for the paving brick, f. o. b. factory, and freight rate to destination, the weight of the bricks must be known to estimate total cost f. o. b. cars at destination. The specific gravity of paving brick ranges from 1.9 to 2.7. Tests of 12 Ohio makes show a range of 1.95 to 2.25.

Assuming a specific gravity of 2.2, a square yard of brick pavers 4 ins. thick would weigh 385 lbs., and a square foot would weigh 43 lbs., as laid with ⅛-in. joints. Whence, by taking from the bidding sheet the number of square yards of pavement and multiplying by 385, the total weight is readily ascertained; or, for all practical purposes, divide the number of square yards by 5, and the quotient will be the number of short tons of freight.

LABOR HOUR REQUIREMENTS ON BRICK PAVEMENT CONSTRUCTION.—D. B. Davis, City Civil Engineer of Richmond, Ind., gave the following in *Roads and Streets:*

In estimating the cost of paving work, while the labor market is constantly changing from month to month, estimators who have an indefinite knowledge of the labor hour requirements for the divisions of work necessary, are liable to have their estimates incompatible with the true value of the work. A knowledge of the labor hours necessary to do a certain work together with accurate market price quotations on the materials which enter into it, will give the estimator much more faith in his estimates.

Although it is commonly conceded that engineers' estimates, on the whole, are not derived from as close a study of the details of the work as a contractor would give to it, there is reason to believe that if a closer study of conditions were made there would be less disparity between their estimates and the contractors' bids.

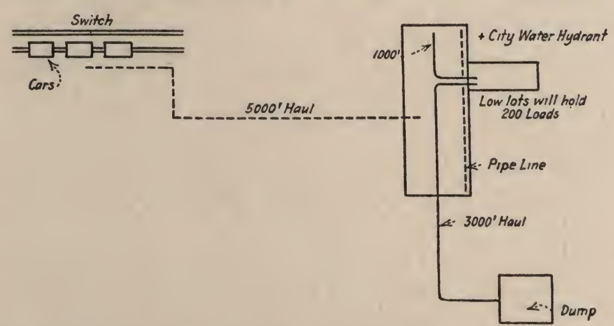


Fig. 1—Sketch Showing Various Conditions Relating to Paving Job

In making an estimate of a certain work a chart showing the various conditions relating to the work will help to guarantee against omission of important details. This chart can be a rough sketch, which in case of a brick paving job in a city, will show the length of haul from the nearest switch to the job; the kind and nearest water supply and other matters of interest one will record on making an inspection of the site. An example of a chart of this kind is shown in Fig. 1.

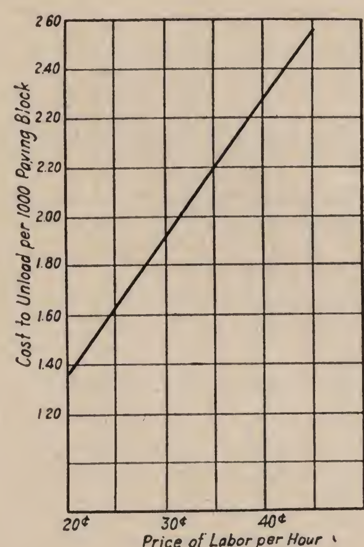


Fig. 2—Cost of Unloading Brick from Cars and on Job
Assumption: 5.7 labor hours per M.

A brief study for determining the labor hour requirements for some divisions of work connected with a brick paving job in a city will be undertaken.

The excavation in this case will be assumed to be completed.

To estimate the cost of unloading and hauling brick from the cars to the job, it is first necessary to figure on the cost of unloading them. It has been the experience of the writer on a number of his jobs that a

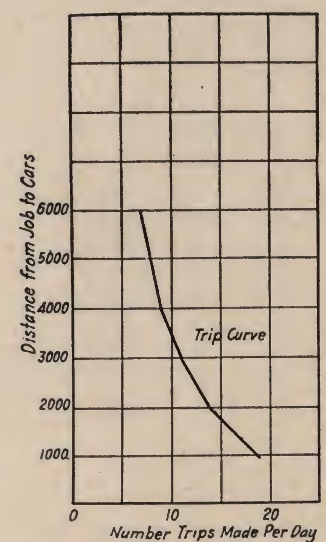


Fig. 3—Curve Showing Number of Loads Per Day

Extra wagons provided to prevent idle time of teams.

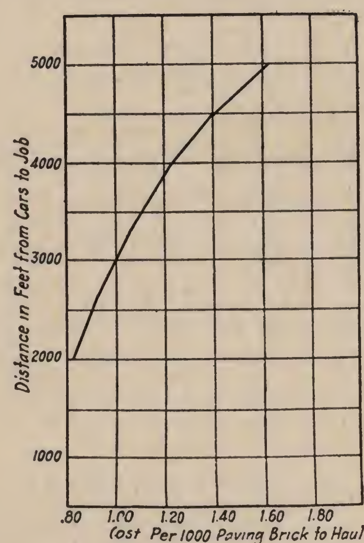


Fig. 4—Cost of Hauling Brick

Team, $8 per day; 665 brick to load

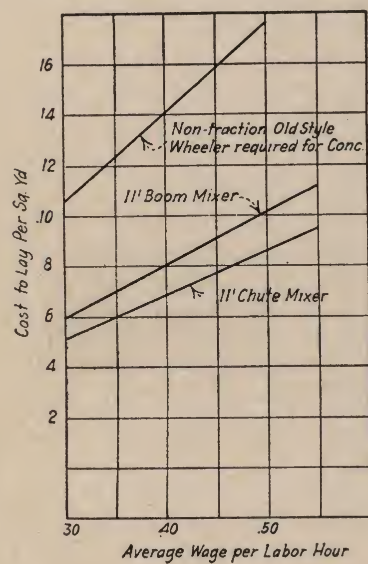


Fig. 5—Cost of Laying 1:7 6-in. Concrete Base

working unit consisting of five men loading from the cars to the wagons and six men at the job, unloading these wagons as they come, will unload approximately on an average of 19,300 paving brick in a 10-hour day. Or it requires approximately 5.7 labor hours to handle the brick from the cars to the pile. Figure 2 shows the cost to unload brick to the pile at different rates of wages for labor.

To haul the brick from the switch to the job, extra wagons are provided, so that the teamster after having hauled the loaded wagon to the street to be unloaded can immediately hitch to an extra empty one and proceed back to the switch. In this way no time is lost while waiting for loading or unloading the wagons.

The number of loads that can be hauled in a given length of time can be determined by the formula:

$$\text{Number of loads hauled} = \frac{T}{\frac{L}{r} - z}$$

In which T=total working time in minutes.
L=length of haul (round trip).
z=lost time in minutes, unhitching, etc. (this will average 17 minutes.)
r=rate of team travel (180 ft. per minute).

Figure 3 shows this formula plotted for different lengths hauls.

Now to find the teams required; find from Fig. 3 the number of trips per day corresponding to the length of haul. Then the number of trips × the capacity of each load equals the number of brick that one team will haul. Then: 19,300 divided by number of brick hauled by one team equals the number of brick required.

Figure 4 shows the cost of hauling brick for various lengths haul. In this case team hire is figured at 80 cents per hour and the capacity of each load at 665 brick.

The total cost of handling and hauling the brick may be found by adding the values from Figs. 2 and 4.

To estimate the labor required to lay a concrete base 6 in. thick the required organization should first be outlined. Such an organization, where the concrete mix is 1 part cement and 7 parts gravel and a 1-sack steam chute mixer is used, is as follows:

1 engineer mixer.	3 gravel wheelers.
1 fireman mixer.	3 gravel shovelers.
2 concrete spreaders.	1 water boy.
1 man handling cement.	1 foreman.

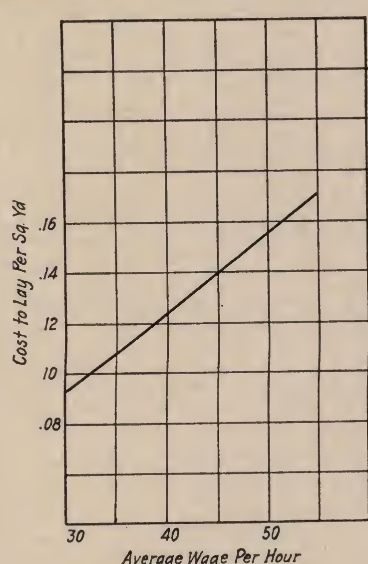


Fig. 6—Cost of Laying Brick

Includes preparing sand-bed, carrying brick, laying brick, batting in closures and foreman. Assumption: 0.31 labor hours per sq. yd.

This gang will lay concrete base requiring approximately 0.20 labor hours per square yard. Figure 5 shows values platted when using a 1-bag chute, 1-bag boom and an old-style non-traction mixer which re-

quires men to wheel the mixed concrete from the mixer to the bed.

To estimate the labor required to lay the brick in the pavement, it is well to remember the divisions of labor required. For the ordinary city pavement it will require five divisions. The following table gives these divisions with coefficients relating to each:

Sand bed mixers	0.00742
Brick carriers	0.01320
Brick setters	0.00214
Batting in closures	0.00200
Cement grouting, by hand mix	0.00797
Cement grouting, machine mix	0.00460

To find the number of men needed for each division of work to balance the whole gang, multiply the required output by the factors opposite each division in the table and take the closest even number.

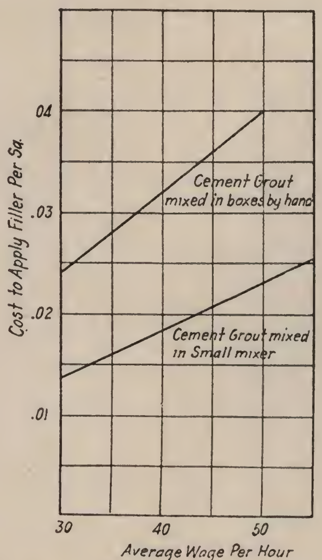


Fig. 7—Cost of Applying Filler to Brick Pavement

Assumption: Mixing by hand, 0.080 hours per sq. yd.; mixing by machine, 0.046 hours per sq. yd.

For example, to find the number of men needed to carry brick in order to lay 1,000 sq. yd. in 10-hour day: Multiply 1,000 yd. by 0.0132, which makes 13.2 or 13 men needed.

Figure 6 shows the costs of laying brick in pavements at different rates of wages. It is figured on the assumption that the operations named require 0.31 labor hours per square yard.

Figure 7 shows the cost of applying cement grout filler. The lower line shows the cost when using a small grout mixer and the upper line shows the cost when using the old style grouting boxes, which require mixing by hand. With labor at 50 ct. per hour it can be seen that a saving of 1¾ ct. per square yard is made by using the gasoline grout mixer.

The labor hours required for these various operations were obtained from the writer's experience and represent work that has been done by energetic, enthusiastic workmen. The proximity which another gang could approach these values would depend wholly on the morale of the workmen and the experience and "pep" of the man in charge.

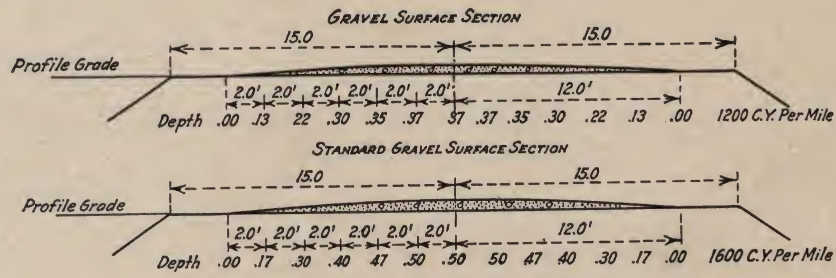
Brick Pavement Miscellaneous Costs

Cost of Laying Bricks, New York State.—On one job, 30,000 "pavers" were laid per day by the gang of 4 bricklayers and 10 men, or 132 sq. yds. per bricklayer. The management was fairly good, but the bricklayers worked with no energy. The other men worked well.

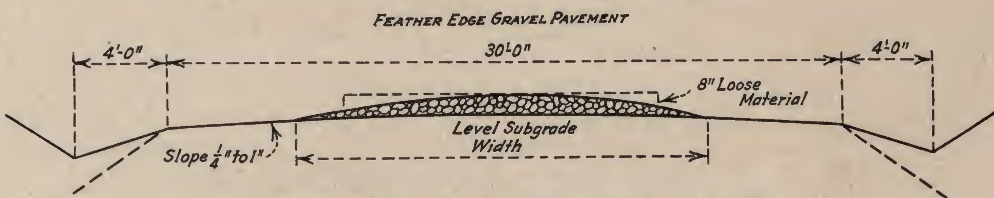
	Cts. per sq. yd.
4 pavers, at $1.00 per hr., each	7.6
3 laborers wheeling, at 50 cts. per hr.	2.7
1 laborer spreading sand, at 50 cts. per hr.	1.0
3 laborers grouting, at 50 cts. per hr.	3.0
2 laborers ramming, at 50 cts. per hr.	1.7
1 laborer raising sunken brick, at 50 cts. per hr.	1.0
1 foreman, at $1.00 per hr.	2.0
Total	19.0

Bricks Laid Per Day Per Man, Jackson, Mich.—In paving a street with shale brick, at Jackson, Mich., there were about 200,000 bricks used for 3,500 sq. yds., or 57.1 bricks per sq. yd. The bricks were 2¾x4½x8 ins., with rounded corners. On a street 42 ft. wide, 6 bricklayers, supplied with brick by helpers, laid 70,000 bricks in 9 hrs. or 11,666 bricks, or 204 sq. yds., per bricklayer. The ordinary average, however, was 7,000 bricks, or only 123 sq. yds., per bricklayer per day. Note that the average day's output was only about two-thirds the best day's output. It is evident that these bricklayers did not exert themselves, for even their best day's record was 204 sq. yds. per layer per day. Twelve boys filled the joints with tar.

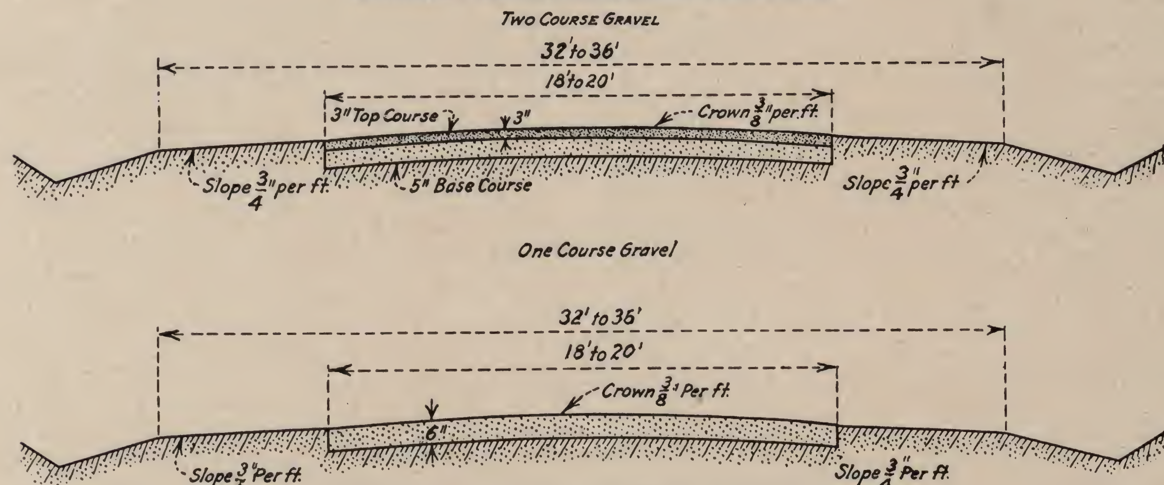
Gravel Roads



STANDARD SECTIONS – MINNESOTA STATE HIGHWAY DEPARTMENT



STANDARD – ILLINOIS STATE HIGHWAY DEPARTMENT



STANDARDS – MICHIGAN STATE HIGHWAY DEPARTMENT

Standard Sections for Gravel Surface and for Course Gravel Pavement

TABLES FOR ESTIMATING GRAVEL ROAD MATERIAL QUANTITIES

Number of Linear Feet of 9-Ft. Road a Load of a Given Size Should Cover For Various Loose Depths

–Weight of load–			—Length spread for loose depth in inches—			
Granite, lb.	Lime-stone, lb.	Size of load, cu. yd.	3-in.	4-in.	5-in.	6-in.
2,800	2,500	1	12 ft.	9 ft.	7.2 ft.	6 ft.
3,500	2,125	1¼	15 ft.	11.25 ft.	9 ft.	7.5 ft.
4,200	3,750	1½	18 ft.	13.5 ft.	10.8 ft.	9 ft.
4,900	4,375	1¾	21 ft.	15.75 ft.	12.6 ft.	10.5 ft.
5,600	5,000	2	24 ft.	18 ft.	14.4 ft.	12 ft.
6,300	5,625	2¼	27 ft.	20.25 ft.	16.2 ft.	13.5 ft.
7,000	6,250	2½	30 ft.	22.5 ft.	18 ft.	15 ft.
7,700	6,875	2¾	33 ft.	24.75 ft.	19.8 ft.	16.5 ft.
8,400	7,500	3	36 ft.	27 ft.	21.6 ft.	18 ft.

Above Weights for Loose Measure.

Approximate Number of Pounds of Gravel and Sand Per Cu. Yd.

Voids	Wt., lbs.	Voids	Wt., lbs.
50 per cent	2240	35 per cent	2910
45 per cent	2460	30 per cent	3130
40 per cent	2680	25 per cent	3350

Number of Cubic Yards of Material Per Mile to Make Given Loose Depth for Various Widths of Road

Depth of loose material in inches	——Width of surfacing——				
	9-ft. cu. yd.	14-ft. cu. yd.	15-ft. cu. yd.	16-ft. cu. yd.	18-ft. cu. yd.
1¼-in. (screenings)	180	280	300	325	367
3-in.	440	684	733	782	880
4-in.	587	913	979	1,043	1,174
5-in.	734	1,141	1,222	1,304	1,468
6-in.	880	1,369	1,466	1,565	1,760
Square yards of surface per mile	5,280	8,213	8,800	9,387	10,560

Gravel Surfacing

Standard Specifications Minnesota State Highway Department

Description: Gravelling shall include all surfacing with gravelly material.

Material: The gravel shall be composed of fragments of hard durable rock of high resistance to abrasion together with sand, clay

or other binding materials. It shall be free from thin or elongated pieces and shall be well graded from coarse to fine.

The gravel when tested by means of laboratory screens shall meet the following requirements:

Passing a one (1) inch screen, not less than 100% of the total sand and silt passing a ten mesh sieve, not more than 15% shall pass a 60 mesh sieve.

Subgrade: The cross sections of the roadway shall be as shown on the standard cross section accompanying the plans. Gravelling upon a wet, muddy roadway will not be permitted. The party of the first part shall shape the roadway to the cross section above mentioned before gravel is placed thereon. Thereafter the Contractor shall keep it dressed to the specified cross section and free from ruts, waves and undulations, as a part of his contract.

Screening Gravel: When the gravel deposit contains stone exceeding one inch in size or one inch in diameter, the gravel must be screened. Screens shall have openings not larger than one inch in diameter. If a "grizzley" is used the space between the bars shall be not more than ¾ of an inch in width.

When the deposit contains an excess of fine material for the subgrade on which it is to be placed, the gravel shall be double screened so as to eliminate the surplus fines. The screening price will not cover double screening unless the special provisions so provide.

Construction Methods: Loading from pits shall be performed in such a manner and by such methods that a uniform grade of material will be delivered on the road. No earth, sod or any other foreign or vegetable matter, or any excess of sand or clay, shall be allowed in the gravel, and care must be taken that strippings are not mixed with the gravel. Any loads taken to the work containing such objectionable materials will be rejected.

Screening shall be performed in such a manner that the material as delivered to the trucks or wagons shall be uniformly graded from coarse to fine.

Where the hauling is done with trucks, trucks with pneumatic tires shall be used unless the roads are frozen. Trucks with solid tires shall be used only with the written consent of the Engineer.

The material shall be deposited in a uniform ridge on the road and shall be spread as directed by the Engineer. In case the material is dumped with such irregularity that additional expense is entailed in spreading, the cost of distributing it longitudinally along the road shall be borne by the contractor.

Shaping and Compacting: The surfacing material shall be shaped while being compacted under travel by the use of a blade grader, tooth harrow, planer or other suitable means. Ruts formed by the hauling or by travel shall be dragged full at least once each day and more frequently if necessary to prevent cutting through the surfacing material into the subgrade. Holes, waves and undulations, which develop and are not filled by planing shall be filled by adding more material according to the direction of the Engineer. The shaping of the material shall be performed according to the direction of the Engineer and shall be continued until the material is well compacted, free from ruts, waves and undulations and is made to conform to the cross section indicated on the standard above mentioned.

Foreign Trucks: When a truck not having proper Minnesota license plates is used, the party of the first part will retain from moneys due the contractor, an amount equal to the license fee for each truck so used, until such time as the Contractor furnishes proof that the license fee has been paid and the license issued. If such proof is not furnished within six months from the time such truck was used, the Contractor shall not be entitled to payment of any money so retained.

Minimum Quantity: The Contractor shall furnish sufficient force and equipment to deliver not less than 400 cubic yards of material per day. In case the Contractor fails to deliver the minimum amount specified, there shall be deducted from any payments due the Contractor, or afterwards becoming due, the sum of 4 cents per cubic yard for each cubic yard less than 400 cubic yards delivered each working day to compensate for the extra expense incurred in keeping a checker upon the work. This provision shall not apply when the hauling is interrupted by inclement weather or soft roads or when the Contractor is obliged, under instructions, to use his force on shaping or other work which breaks up his hauling organization.

Measurement: The capacity of the gravel hauling vehicles shall be measured by the Engineer or inspector. The measurements shall be to the nearest one-tenth (0.1) cubic yard capacity and the capacity of a vehicle, once measured, shall not be changed without the consent of the Engineer.

Loads will be measured at the point of dumping on the road and the Contractor shall level all loads before they are checked by the inspector.

Payment will not be made for material heaped above the water level capacity of the box and deductions will be made in one-half cubic yard units for loads which do not contain the full water level capacity of the box.

Basis of Payment: (a) The necessary stripping of gravel pits will be paid for by the cubic yard measured in excavation. Stripping materials shall be disposed of as directed by the Engineer, the free haul not to exceed two hundred (200) feet. Overhaul shall be paid for at the rate of two (2) cents per cubic yard for each additional one hundred (100) feet.

(b) All surfacing material will be furnished free to the Contractor by the party of the first part in the pit or stock pile, or F. O. B. cars at the nearest railway siding. When it becomes necessary to deliver material by rail and delivery in this manner is not provided for in the plans, the necessary unloading from cars to the stock pile shall be paid for as specified under Section (1-32) of these specifications. Loading from stock pile or from cars direct to hauling equipment shall be included under the contract price bid.

The right is reserved to change gravel pits from those shown on the approved plans, subject to the provisions of Sections (1-30 and 1-31) of these Specifications.

(c) Prices submitted in the proposal or included in the contract for screening, loading and hauling, shall cover the furnishing of all labor and equipment necessary to load and screen the material as furnished by the party of the first part and also transport and deposit it upon the road in the manner specified. Payment will be made in the following manner for screening, loading and hauling:

1. When screening is required the contract price per cubic yard will be paid on the number of cubic yards of screened material placed on the road as determined under S3-9 (paragraphs above on Measurement). Such price shall include the disposal of the rejected material, except that haul required beyond 200 feet will be paid for on the basis specified for stripping overhaul.

2. Loading will be paid for at the contract unit price per cubic yard on the yardage as determined under S3-9 (paragraphs above on Measurement).

3. Hauling will be paid for at the contract unit price per cubic yard mile, the number of cubic yard miles being determined by multiplying the number of cubic yards hauled by the average haul of the material.

4. Unless otherwise specified the unit price bid for hauling shall include the building of such road or roads as may be necessary to reach the pit and the maintenance necessary to keep and leave all town, county and State roads in as good condition as when hauling started. The right-of-way necessary for hauling from pit to the road will be furnished by the party of the first part.

5. In all cases the inspector will act as timekeeper for the party of the first part, and will determine and record the nature and amount of the force account work done by the Contractor in spreading, shaping and compacting.

Gravel Surface Course

Standard Specifications Vermont State Highway Department

Description: This item shall consist of a wearing course composed of gravel, and shall be constructed on the prepared subgrade, or completed base course, in accordance with these Specifications and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

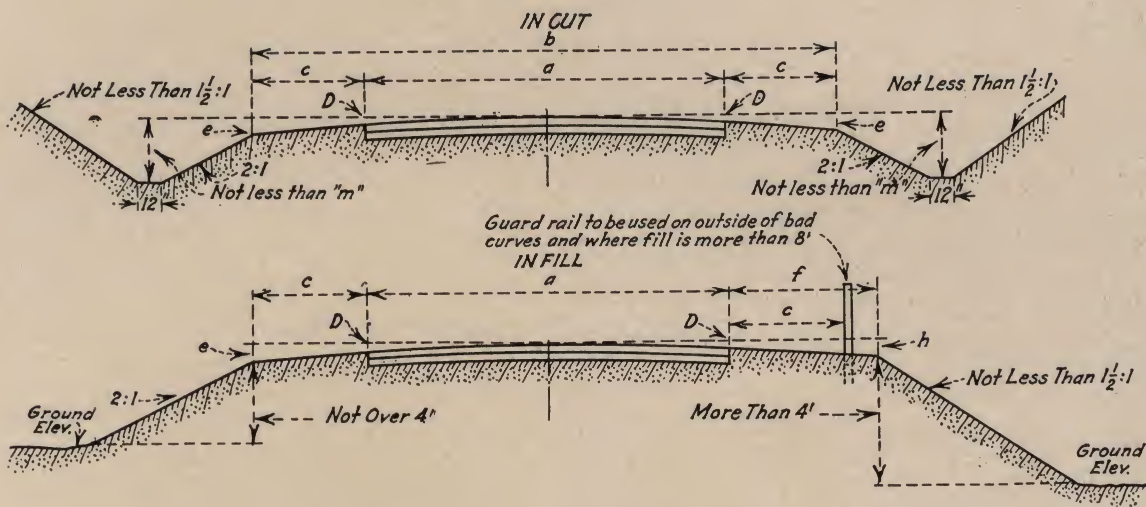
Materials: The gravel shall be of hard, durable rock together with the sand and clay or other approved binding material and shall be free from thin or elongated pieces. It shall be of such sizes for top course that all will pass through a one (1) inch circular opening, and not less than thirty-five per cent (35) be retained on a ¼ inch screen and of such sizes for bottom course that all will pass through a 3½ inch circular opening, and not less than forty per cent (40%) be retained on a ¼ inch screen and for either course, it shall be uniformly graded. The finer material shall consist of sand and clay or other binding material approved by the Engineer. Should the "run of the bank" for any reason or at any time during the work fail to maintain suitable proportions of coarse and fine particles, or should the coarse particles not be uniformly graded between the maximum and minimum sizes as specified, it shall be screened, or manipulated in such a manner as to furnish a material meeting the above requirements. If the "run of the bank" is too fine, it shall be screened in such a manner as to remove sufficient fine material to make the product meet the above requirements, or coarse material from some other source shall be added to get the same results. If the "run of the bank" contains ten per cent (10%) or more coarse material not passing a 3½ inch circular opening, the whole material from the bank shall, if required by the Engineer, be passed through a crusher whose jaws are adjusted in such a way as to get a product meeting the above requirements for the percentages of coarse and fine material, but the maximum size of the product shall be such that all will pass a one (1) inch circular opening for the top course and a three (3) inch circular opening for the bottom course.

Method of Construction. The gravel shall be laid in two courses unless otherwise shown on the Plans. After the subgrade or foundation course shall have been properly prepared and proper drainage provided, the gravel shall be spread evenly by means of approved spreader wagons or trucks or from dumping platforms and the loads shall be so dumped that the entire load will be rehandled to put it in place so that it will have, after compacting, the required thickness. No segregation of large or fine particles shall be allowed, but the gravel as spread shall be well graded, with no pockets of fine material. The gravel after being placed shall be so manipulated as to be thoroughly compacted, and any depressions that may appear shall be filled and again compacted. After the bottom course has been properly laid and rolled or otherwise satisfactorily compacted, the top course may be spread and compacted to a thickness as shown on the Plans or ordered by the Engineer.

Method of Measurement: This item shall be measured by the cubic yard compacted complete in place. No allowance will be made for material forced into the subgrade, and the dimensions used for thickness will not exceed those shown on the Plans or ordered by the Engineer.

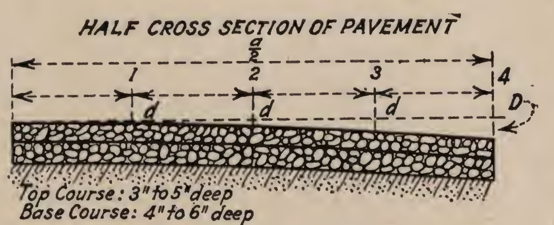
Basis of Payment. The quantity to be paid for under this item shall be the number of cubic yards of compacted material in place complete. The price bid shall cover the furnishing, placing, filling and compacting of the material and all labor and incidental expenses necessary to complete the work.

Waterbound Macadam



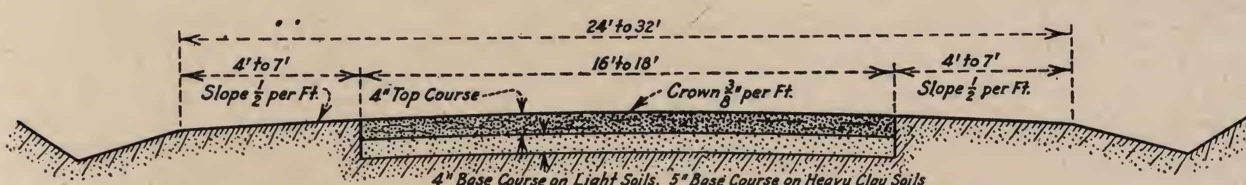
Crown Detail

Width of Pavement	d to 1 2/14D	d to 2 5/14D	d to 3 9/14D	d to 4 14/14D
16'-0"	¼"	½"	1"	1½"
18'-0"	¼"	⅝"	1⅛"	1¾"
20'-0"	¼"	¾"	1¼"	2"



a	16'	18'	20'
b	28'	30'	32'
c	6'	6'	6'
D	1½"	1¾"	2"
e	6"	6¼"	6½"
f	7"	7"	7"
h	6¾"	7"	7¼"
m	27"	27"	27"

Standard Design of Ohio State Highway Department for Waterbound Macadam.



Standard Design of Michigan State Highway Department for Waterbound Macadam

QUANTITIES FOR ESTIMATING PURPOSES

CUBIC YARDS PER MILE

Width Ft.	Thickness In.	Cu. Yd.	Width Ft.	Thickness In.	Cu. Yd.
9	2	293	16	2	522
9	2½	367	16	2½	652
9	3	440	16	3	782
9	4	587	16	4	1043
9	6	880	16	6	1564
9	7	1027	16	7	1825
9	8	1173	16	8	2086
9	9	1320	16	9	2347
15	2	489	20	2	652
15	2½	611	20	2½	815
15	3	733	20	3	978
15	4	978	20	4	1304
15	6	1467	20	6	1956
15	7	1711	20	7	2281
15	8	1956	20	8	2607
15	9	2200	20	9	2933

CUBIC YARDS PER 1,000 TO 20,000 SQ. YDS.

Sq. Yds.	Thickness—Inches 4	5	6	7	8	9
1000	111	139	167	194	222	250
2000	222	278	333	389	444	500
3000	333	417	500	583	667	750
4000	444	556	667	778	889	1000
5000	556	694	833	972	1111	1250
6000	667	833	1000	1167	1333	1500
7000	778	972	1167	1361	1556	1750
8000	889	1111	1333	1556	1778	2000
9000	1000	1250	1500	1750	2000	2250
10000	1111	1389	1667	1944	2222	2500
12000	1333	1667	2000	2333	2667	3000
14000	1556	1944	2333	2722	3111	3500
16000	1778	2222	2667	3111	3555	4000
18000	2000	2500	3000	3500	4000	4500
20000	2222	2778	3333	3889	4444	5000

SPREAD OF STONE

From Road and Pavement Data Book of the Amiesite Asphalt Co.

Kind	Wt. Per Cu. Yd.	Spread, Loose Fill, Sq. Yds. Per Cu. Yd. 2-in.	3-in.	4-in.	5-in.	6-in.	7-in.	8-in.
Granite	2845	18	12	9	7.2	6	5.1	4.5
Limestone	2845	18	12	9	7.2	6	5.1	4.5
Sandstone	2511	18	12	9	7.2	6	5.1	4.5
Trap	3095	18	12	9	7.2	6	5.1	4.5

Based Upon 38 Per Cent Voids

Kind	Cu. Ft. Per Ton	Spread, Loose Fill, Sq. Yds. Per Ton 2-in.	3-in.	4-in.	5-in.	6-in.	7-in.	8-in.
Granite	18.98	12.65	8.44	6.33	5.05	4.22	3.62	3.16
Limestone	18.98	12.65	8.44	6.33	5.05	4.22	3.62	3.16
Sandstone	21.5	14.33	9.56	7.17	5.73	4.78	4.10	3.58
Trap	17.45	11.63	7.76	5.82	4.76	3.88	3.32	2.90

APPROXIMATE AMOUNT OF FILLER REQUIRED FOR CRUSHED STONE MACADAM BOTTOM COURSE, USING 0.35 CU. YD. FILLER PER CU. YD. ROLLED BOTTOM

From Harger's Rural Highways

Width Macadam Ft.	Rolled Depth of Bottom Course (Cubic Yards per 100 Ft. of Road) 3-in.	4-in.	5-in.	6-in.
10	3.2	4.3	5.4	6.6
12	3.8	5.1	6.5	7.6
14	4.5	6.0	7.5	9.0
15	4.9	6.4	8.0	9.9
16	5.2	6.9	8.6	10.4
18	5.9	7.9	9.7	11.8
20	6.4	8.6	10.8	12.8
22	7.0	9.4	11.8	14.2

Waterbound Macadam Pavement

Description: This pavement shall consist of a two (2) course wearing surface of the dimensions indicated on the plans, composed of coarse material and stone, gravel or sand filler, constructed on the prepared subgrade in accordance with these specifications, and in conformity with the line, grade, compacted thickness and typical cross-section shown on the plans.

Materials: *The materials for this work shall conform to the following requirements:*

(a) ***Coarse material*** *shall be Grade C, 3-inch stone conforming* to the following requirements:

Broken Stone. The grade and sizes of broken stone required for the different items are specified under those items. Broken stone shall be obtained from clean, tough, durable rock; it shall be crushed by the most approved modern machinery and shall have a per cent of wear and a toughness conforming to the requirements as stated in Table I for the grades of stone specified. All Dolomites and Limestones must be of such density that they will not be noticeably affected by five (5) immersions in a saturated solution of sodium sulphate with proper dehydration after each immersion.

Broken stone, regardless of grade, must contain not more than five (5) per cent of weathered or partly decomposed rock. When intended for use in concrete work or to be coated with bituminous material, it must be free from pieces coated or partly coated with mud, dust or foreign material.

The stone shall be screened accurately to the size specified for each size in the following Table II. This table shows the minimum and maximum percentages passing the various laboratory screens having circular openings of the diameter states. The Contractor or producer shall use the size, length and character of screen and method of crushing and screening that is best suited to produce the different sizes of broken stone as specified.

Broken stone must not contain more than five (5) per cent of flat or elongated pieces, the width of which is less than fifty (50) per cent of the length. The various stone fragments comprising any particular class shall be uniformly distributed throughout the mass of stone as shipped. When two or more sizes of stone are mixed to secure any particular class, the mixing shall be done before the stone is loaded into the shipping vehicle.

TABLE I

Grades	Per cent of Wear —not more than	Toughness— not less than
Grade A	3.3	12.0
Grade B	4.5	6.0
Grade C	5.5	6.0

TABLE II

Class	Per Cent Passing Screens 3½″	3″	2½″	1½″	1″	¾″	⅝″	½″	⅜″	¼″
3″ stone	100			0-15		0				
2½″ stone		100			0-15	0				
2″ stone			100	0-15		0				
1¼″ stone				100	0-15	0				
¾″ stone					100		0-15			
½″ stone							100		0-15	0-5
Screenings									100	
Concrete stone			100	50-75	10-20			0-5		

or, at the option of the Engineer, 3-inch crushed gravel conforming to the following requirements:

Crushed gravel shall consist of clean, hard, durable, uncoated pieces having a per cent of wear of not more than fifteen (15) (abrasion test for gravel) and shall be free from an excess of soft, thin or laminated pieces, disintegrated stone, dirt, or organic or other injurious matter occurring either free or as a coating on the stone. When used in conjunction with reinforcing steel, the gravel shall be free from salt or alkali. It shall contain not less than fifty (50) per cent of pieces that have been broken by the crusher.

(b) **Stone or gravel filler** shall consist of a well graded mixture of Grade C, ½-inch stone and Screenings, or ½-inch crushed gravel and Screenings, conforming to the requirements of the above Specifications, respectively when local material is used. When stone is obtained from a commercial quarry, Grade C Screenings conforming to the requirements of paragraph (a) above shall be used.

(c) **Sand filler** shall consist of Filler Sand conforming to the following requirements:

Filler sands are those intended for use in the construction of broken stone base courses, gutters, and for such other miscellaneous purposes as may be defined herein. They shall be composed of clean, hard, durable grains, graded from coarse to fine, shall be free from loam or any foreign substances and shall be approved by the Engineer for the use intended.

Note: In case local wall, field or ledge stone is used, the entire run of the crusher up to sizes passing a screen having circular openings three and one-half (3½) inches in diameter shall be used and paid for at the contract unit price per ton for "Broken Stone" complete in place. Broken stone of sizes other than those specified above shall be used as directed by the Engineer.

Spreading Coarse Stone. The prepared base course or subgrade shall be cleaned of all foreign substances and the coarse stone shall be spread upon it with shovels from piles along the side of the roadway or from dumping boards. It may be spread directly from approved vehicles constructed especially for this purpose, but in no case shall the stone be dumped directly on the subgrade, except from patented spreading wagons. The stone for the first, or base course, shall be spread first to such a depth that this course will be four (4) inches in depth after final rolling unless otherwise specified. All segregated fine or coarse stone shall be removed and replaced with well graded stone. After the stone for the bottom course has been spread, it shall be filled while being rolled, with screenings or sand. The rolling shall continue until the filler has been thoroughly forced into the voids in the coarse stone. The second or wearing surface course shall then be applied, the coarse stone being first spread to such a depth that this surface course *will be three (3) inches in depth after final rolling unless otherwise specified and then rolled and filled as specified for the first course.*

Rolling Coarse Stone. The coarse stone shall be rolled with a three (3) wheel power roller weighing not less than ten (10) tons, until it is compacted to a firm even surface. The rolling shall begin at the sides, overlapping the shoulder for a distance of not less than six (6) inches, and progress to the center, parallel with the center line of the roadway, uniformly lapping each preceding track and covering thoroughly the entire surface with the rear wheels, and continuing until the stone does not creep or wave ahead of the roller. The rate of rolling shall be such that one roller shall not complete the rolling of more than one hundred (100) square yards of finished surface per hour.

Application of Filler. After the coarse stone has been rolled satisfactorily, filler shall be spread with shovels from piles along the side of the roadway or from dumping boards, but in no case shall the filler be dumped directly upon the surface of the coarse stone. Filler shall be spread in thin layers, longitudinally, that is, lengthwise of the road, and each layer rolled dry, this process being continued until no more filler can be forced into the voids, after which the surface shall be sprinkled with water and rolled. The sprinkling and rolling shall be continued and the additional filler applied where necessary until all the voids are filled and until a slight wave of excess water and filler forms a grout in front of the roller wheels. Hand brooms shall be used to sweep the filler into the unfilled voids and to distribute them evenly. After the wave of grout has been produced over the whole section of the macadam, this portion shall be left to dry, after which it may be opened to traffic. The macadam shall be sprinkled and rerolled on succeeding days as much as may be necessary to bond it thoroughly and secure a satisfactory surface. The quantity of filler and water used shall be determined by the Engineer and shall be sufficient to produce a smooth, hard, monolithic surface. The rolling in all cases shall begin at the sides, overlapping the shoulders and progress to the center of the roadway, thoroughly covering the entire surface with the rear wheels.

Finishing. If at any time, the base course material should become churned up or mixed with the surface course material, the Contractor shall without additional compensation, dig out and remove the mixture of base and surface course materials and replace the material removed with approved clean base course and surface course materials, respectively, which shall be tamped, rolled and filled until compacted thoroughly, uniform with the surrounding surface. If any irregularities appear during or after rolling this course, they shall be remedied by loosening the surface and removing or adding coarse stone, as may be required, after which the entire area including the surrounding surface shall be rolled, filler and water applied, and the rolling continued until it is compacted satisfactorily to a uniform surface.

Basis of Payment. This work will be paid for at the contract unit price per ton for "Broken Stone" complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto.

Estimating Cost of Water Bound Macadam

Units Used in Measuring Macadam. Due to the fact that macadam is measured in various ways by different engineers, there has been much confusion in recording costs. The following are some of the different units that engineers have used:

(1) Cu. yd. of consolidated macadam, measured in finished road.

(2) Cu. yd. of loose stone, including screenings, measured in wagons

(3) Cu. yd. of loose stone, measured on the road, but not including screenings or binder.

(4) Sq. yd. of consolidated macadam.

(5) Sq. yd. of loose stone (sometimes excluding screenings).

(6) Ton (usually 2,000 lb, but sometimes 2,240 lb.) of stone used to make the macadam, usually including the screenings or binder, but not always.

In view of the great uncertainty as to what may be meant by the expression "cubic yard of macadam" or "cubic yard of stone," every writer should be careful to tell exactly what he means.

Of the various units above mentioned, I prefer the first—the cubic yard of compacted macadam.

However, the ton of 2,000 lb. is often a convenient unit for measuring the material in a macadam road, and is also likely to be used extensively. When the ton is used as the unit, care should be taken to give the weight of the loose broken stone per cubic yard, so that conversions can be made.

Since loose broken stone consolidates about 10 per cent when hauled a short distance in a wagon or car, care should be taken to state where the measurement of volume was made.

Macadam roads vary so greatly in thickness, that it is particularly desirable to use the cubic yard of consolidated macadam as the unit, instead of the square yard; but the thickness of the macadam, after compacting, should always be stated, for the per cent of screenings, or binder, varies with the thickness, and the amount of rolling is less per cubic yard for thick macadam than for thin macadam.

Items of Cost of Macadam. The following are all the items usually involved in macadam construction done by a contractor:

Materials:

- Broken stone (coarse).
- Screenings, or binder.
- Freight on stone and screenings.
- Water for sprinkling.

Labor:

- Loading stone and screenings into wagons.
- Hauling stone and screenings.
- Spreading stone (coarse).
- Spreading screenings, or binder.
- Rolling.
- Sprinkling.
- Foreman.

General Expense:

- Superintendent, watchman, waterboy, timekeeper, and clerks, insurance of workmen, etc.

Supplies and Plant:

- Coal or gasoline for roller.
- Oil and waste for roller.
- Interest, depreciation and repairs on roller.
- Interest, depreciation and repairs on wagons.
- Interest, depreciation and repairs on small tools.

In the foregoing summary, it is assumed that the broken stone and screenings are either purchased, or that, if quarried and crushed by the contractor himself, the cost of quarrying and crushing is kept entirely separate from the cost of building the macadam.

It is also assumed that the grading, including preparing the sub-grade, is likewise kept separately, for to do otherwise leads to great confusion, as the yardage and cost of grading have no relation whatsoever to the yardage of macadam and its cost.

While the size of each particular job should be recorded, stating length, width and thickness of the compacted macadam, writers only confuse their records by giving *total costs* of each of the above items. What a reader desires is *unit costs*, that is the cost of each item in terms of the cubic yard of compacted macadam as the unit. Then, if the writer has stated the total number of cubic yards involved, it is a simple matter of multiplication to arrive at total costs, should anyone desire totals.

Quantity of Stone and Binder Required for Macadam. Many years ago I called attention to an error that had been copied in text books from a very early day, namely the statement that a layer of loose stone 6 in. thick can be compacted under a roller till it is 4 in. thick. No such compression is possible, but it often happens that the stone is driven 1 to 2 in. into the subgrade. On a hard earth subgrade, it never requires more than 1.3 cu. yd. of coarse loose stone (exclusive of the screenings or binder) to make 1 cu. yd. of rolled or compacted stone, and where the stone is very tough the "compression" is even less.

The percentage of binder or screenings required to fill the voids in the rolled stone varies somewhat with the thickness of the macadam. *To ascertain the thickness of the coat of screenings necessary to fill the voids in the rolled stone, divide the thickness of the rolled stone by 4 and add ⅓ inch.* Thus, for a 6-in. macadam road, there will be required $(6 \div 4) + \frac{1}{3} = 1\,5/6$ in. of screenings. This is equivalent to 0.3 cu. yd. of screenings per cu. yd. of macadam. Therefore, to make a cubic yard of finished 6-in. macadam requires 1.3 cu. yd. of coarse stone and 03 cu. yd. of screenings, or 1.6 cu. yd. measured in the wagons to make 1 cu. yd. of compacted macadam Stated differently:

7.8 in. of loose stone (½ to 2½-in.) will roll to 6 in.
1.8 in. of screenings (less than ½-in.) will fill voids.

—

9.6 in. of loose stone and screenings will make 6 in. of macadam.

If the stone weighs 2,400 lb. per cu. yd., we need 1.56 short tons of coarse stone and 0.36 short ton of screenings, a total of 1.92 tons required to make 1 cu. yd. of finished macadam. If the stone is a heavy trap rock weighing 2,700 lb. per cu. yd., we need 1.75 short tons of coarse stone and 0.41 short ton of screenings, a total of 2.16 tons per cu. yd. of finished macadam. This estimate, based upon my own records, checks very well with records published by the Massachusetts Highway Commission.

On 2.6 miles of 6-in. New York State macadam, 1,600 cu. yd. of screenings were required to bind 4,000 cu. yd. of macadam rolled in place. This is equivalent to 0.4 cu yd. of screenings per cu. yd. of macadam, or a depth of 2.4 in. of loose screenings to bind the 6 in. of rolled macadam. This large amount was due to the specification requirements that a "wearing coat" of screenings be left on the road.

The contractor is cautioned against careless examination of road specifications, for many engineers require the contractor to grade the subgrade exactly to grade and then put on enough stone to bring the

finished macadam up to the established road grade. This causes the contractor to lose all stone that is driven into the subgrade by the roller, which in sand, or in soft wet clay, may amount to 2 in. or more of loose stone.

Some specifications also foolishly require a ½-in. "wearing coat" of screenings to be left on the finished road, and this also amounts to a good many cubic yards of wasted material in a mile.

The roadmaker will do well to carry in mind the following data: *A bed 1 in. thick, 10 ft. wide and a mile long, contains 163 cu. yd. A bed 6 in. thick, 16 ft. wide and a mile long, contains 1,564 cu. yd.*

Few rocks are soft enough to yield a sufficiently large percentage of screenings to bind the macadam; in which case screenings must be imported, unless the specifications permit the use of loam, sand, or clay.

Cost of Loading Stone From Cars Into Wagons. A good workman, shoveling stone from a flat car into a wagon, will load 20 cu. yd. (loose measure) per 10-hr. day.

Cost of Loading Stone From Bins Into Wagons. If the broken stone is to be hauled direct from the crusher, bins should always be erected to receive the broken stone. The bottom of the bin should have a slope of not less than 1 to 1, and should be lined with sheet iron. If the slope is flat, say 1½ to 1, a wagon cannot be loaded in much less than 7 min., and then a potato-hook or hoe must be used to keep the stone moving. But, with a 1 to 1 slope, the stone runs freely, and a wagon can be loaded with 1½ cu. yd. in 2 min. or less.

Usually one man operates the bin gates and assists the driver in trimming the load on the wagon. Hence the unit cost of loading from bins is the wages of the bin man divided by the total number of cubic yards crushed daily.

Cost of Hauling Stone in Wagons. When wagons are loaded from cars, it is not economic to have more than 4 men shoveling into a wagon. These men will load a cubic yard of broken stone in about 6 or 7 min., if working briskly. If the loading is done from bins, the lost team time is about 1½ min. per cu. yd.

The lost team time at the dump is 5 min. for a load of 1½ cu. yd., or more than 3 min. per cu. yd., if slat-bottom dump wagons are used. In dumping from a slat-bottom wagon, dump the load in 3 small piles, to reduce the labor of spreading.

In dumping stone from bottom dump wagons, fasten a chain around the body of the wagon so that the bottom doors can open only 6 in. when the load is dumped, and keep the team traveling while dumping, so as to spread the load as much as possible. When such wagons are used, there is practically no lost team time dumping.

Special "spreader wagons" are frequently used, and, in that case also, there is practically no lost team time dumping the load.

One and one-half cu. yd., or 1.9 tons, is a common load of broken stone hauled over earth roads, and a common speed is 2½ miles per hr., or 220 ft. per min.

If the earth roads are level and in good condition, a load of 2 cu. yd. may be hauled.

If the haul is over a good macadam road, 3 cu. yd., or 3.7 tons may be hauled, but it often happens that specifications foolishly prohibit any hauling over macadam before the rolling has been completed, in which case the contractor must usually begin construction at a point far from his stone supply and build the road back toward the stone supply, thus hauling over earth the entire distance, and doubling the cost of hauling.

In estimating the average length of haul on roadwork, bear in mind that the haul is never constant, and that at times the work will be too great for 5 teams, for example, but not enough to keep 6 teams fully busy. After estimating the cost by the above rules, for the actual average haul, I consider it fair to add about 15 per cent to cover the added cost due to variable haul, and the added cost of team time due to delays at the crusher.

Cost of Spreading Stone By Hand. When the stone is dumped in comparatively small piles on the subgrade, one man will spread 25 cu. yd. of the coarse broken stone in 10 hr., at a cost of 18 ct. per cu. yd. when wages are $4.50. This is my own record for several thousand yards of stone delivered in slat-bottom wagons. Subsequently I developed the method of machine spreading, described hereafter, which greatly reduced the cost.

The following records confirm my own, all being recorded in *Roads and Streets.*

Mr. Curtis Hill states that each man averaged 28 cu. yd. per day, in Missouri.

Mr. A. N. Johnson states that in spreading 44,000 cu yd., 25 cu. yd. were spread per man per day.

Mr. W. W. Crosby gives records for negro labor in Maryland, showing an average of 22 cu. yd. per man per 10-hr. day.

The foregoing show what may be accomplished with energetic workmen, but there are numerous instances where the cost of spreading has been three times as high. For example, Mr. John McNeal states that in spreading stone by city day labor on 14,000 sq. yd., in Easton, Pa., each man spread only a little more than 8 cu. yd. of loose stone per 10-hr. day.

However, a high cost of spreading is not of itself evidence of inefficiency. It frequently happens that engineers foolishly require all stone to be dumped upon platforms alongside the road, whence it is shoveled onto the road. In such cases, a man will not shovel and spread more than about 12 cu. yd. per day.

According to a common method of building a macadam road, the coarse stone is dumped in piles upon the subgrade, and spread with shovels and rakes. The screenings, however, are dumped in piles on the earth shoulders, and not on the subgrade. Then they are shoveled onto the coarser stone after it has been spread and well packed by rolling. This shoveling and spreading of the screenings costs much more per cubic yard of screenings than it costs to spread the coarse stone. A man will spread about 10 cu. yd. of screenings per 10-hr. day.

Cost of Spreading Stone With a Leveler or Grader. A "leveler" is a light machine having a steel blade about 5 ft. long, mounted in a frame, and capable of being raised or lowered. One team pulls the machine, and a man operates it. With such a leveler 50 cu. yd. can readily be spread per hour from small piles dumped on the subgrade. However, the spreading thus done by the "leveler" is not as true to surface as is necessary before rolling, so the layer of stone must be gone over by a man using a potato-hook for a rake. This final hand leveling adds another 3 ct. per cu. yd. The screenings cannot be spread satisfactorily with the machine, but they constitute only a small percentage of the macadam.

I have known contractors who have attempted to improve on this method by using a large "road machine," but never with as satisfactory results. The four to six horses on a road machine add unnecessarily to the cost for this light work of spreading stone. Moreover, a road machine is not turned around so easily and quickly, and the turning around is apt to tear up the subgrade.

Due to the speed at which a leveler works, it is unnecessary to have a team constantly hitched to it. I prefer to unhitch a team from the sprinkler wagon at intervals during the day, for a few minutes at a time, and hitch it to the leveler.

For the best results at the lowest cost, dump the

broken stone on the subgrade in as small piles as possible. Never dump the stone on the earth shoulders at the side of the road.

Cost of Rolling. Based upon my own records of cost of maintaining and operating steam rollers (10-ton), the following is the cost per day actually worked.

	Per day
Engineman	\$7.00
0.35 ton (700 lb.) coal	2.80
Oil, etc.	.50
800 gal. (3¼ tons) water pumped and hauled 1 mile	2.00
Interest, 6 per cent of \$5,000÷100 days	3.00
Current repairs and renewals, 5 per cent of \$5,000÷100 days	2.50
Depreciation (life of 25 years; sinking fund, 3 per cent compound), 2.75 per cent of \$5,000÷100 days	1.40
Total	\$19.20

It will be noted that I have assumed only 100 days per annum actually worked by a roller. In the northern half of America the road building season is not long enough to permit working much more than this; but it will sometimes happen that work is started early enough to enable at least 120 days to be worked, after deducting time lost on account rains, etc.

Having established an approximate cost of \$20 per day worked, for operating and maintaining a roller, the next step is to determine the fair average yardage of macadam compacted per day. A roller can be counted upon to compact all the stone crushed by a 9x16-in. jaw crusher, where the crusher is working on hard quarry stone and averaging about 65 cu. yd. of loose broken stone and screenings per 10-hr. day. These 65 cu. yd. of loose stone will make 40 cu. yd. of compacted macadam, or 240 sq. yd. of macadam 6 in. thick. Hence the cost of rolling is about 30 ct. per cu. yd. of loose stone (including screenings), or 50 ct. per cu. yd. of compacted macadam, or 8½ ct. per sq. yd. of compacted macadam 6 in. thick. This cost includes the ordinary steam rolling given to the subgrade before spreading the broken stone.

If the subgrade is very compact, or if new macadam is being laid on old macadam, a roller is capable of consolidating 50 per cent more than the above given amount. On the ordinary soil, even ofter rolling it with a corrugated roller or a steam roller, the broken stone does not come to rest quickly under rolling, but waves under the roller for a long time. If the subgrade has been tamped with a rolling tamper, however, the average soil is so compacted that the broken stone is not driven into it, and the amount of steam rolling of the macadam is very greatly reduced.

One of my records shows that in 72 working days of 8 hr. each, a 10-ton roller compacted 4,000 cu. yd. (24,000 sq. yd.) of 6-in. macadam, the subgrade being a compact gravelly soil. This is equivalent to 55 cu. yd. of compact macadam, or 330 sq. yd., per 8 hr. day, or nearly 7 cu. yd. or 42 sq. yd. per hr. This is a rapid rate, but is still far below the rate that I secured in resurfacing an old macadam that had been thoroughly broken up with picks, namely, 300 sq. yd. per hr.

In rolling 6-in. macadam at Hudson, N. Y., Mr. H. K. Bishop found that 60 cu. yd. of compacted macadam, or 360 sq. yd., was the average 8-hr. day's work of a 10-ton roller, which is equivalent to 45 sq. yd. per hr.

Mr. F. G. Cudworth states that in resurfacing an old macadam, 3.9 in. of loose trap rock and 2.1 in. of screenings were spread and rolled, the 10-ton roller averaging 472 sq. yd. per 10-hr. day.

Mr. W. C. Foster states that, in resurfacing an old macadam, a 12-ton roller averaged 314 sq. yd. of 6-in. macadam per 10-hr. day.

Mr. Curtis Hill states that in building a new 7 in. macadam road in Missouri, 65 cu. yd. of loose stone (the full output of the crusher) were rolled per day.

Mr. John McNeal states that in building new 6-in. macadam streets at Easton, Pa., a 12-ton roller averaged 200 sq. yd. per day, although on one street the average was 270 sq. yd. per day. The work was done by day labor, which accounts for the low average.

Mr. W. W. Crosby states that in building a new 6-in. macadam road in Maryland, 300 sq. yd. were rolled per day of 10 hr., less than 0.2 ton of coal being used by the roller.

If macadam is to be of thickness greater than 6 in. (measured after rolling), it is usually built in two layers. It is evident that the top layer will require less rolling than the lower layer.

Cost of Sprinkling. The amount of water used per cubic yard of macadam is exceedingly variable, depending largely upon the nearness of the water supply and the whim of the inspector. If the haul for the water is short, it is usually economy to use an abundance of water, for water washes the screenings into the voids of the coarse stone ("puddles"), and reduces the amount of rolling necessary to jar the screenings into the voids. I have used as low as 30 gal. per cu. yd. of compacted 6-in. macadam, which is equivalent to 5 gal. per sq yd.; and I have used as high as 120 gal. per cu. yd., or 20 gal. per sq. yd. of 6-in. macadam. It is usually safe to estimate on not more than 10 gal. per sq. yd. of 6-in. macadam, or 60 gal. per cu. yd. of compacted macadam.

The following records are taken from *Engineering and Contracting.*

Mr. A. L. Valentine states that in building a 6-in. macadam road near Seattle, 9.3 gal. were used per sq. yd. Mr. W. W Crosby states that 20 gal. per sq. yd. were used on a 6-in. macadam road in Maryland.

Mr John McNeal states that, in one case, 16.8 gal. were used per sq. yd. of 6-in. macadam, and that, in another case, 16 gal. were used per sq. yd. of 10-in. macadam street.

In road building it is usually necessary to pump the water by hand, or with a small gasolene pump, from a creek, river or well. In 10 hrs. one man, with a hand pump, will raise 7,500 gal. of water to a height of 16 ft. into a tank from which it can be drawn off into the sprinkling wagon. Hence by working 3 hrs. a day, a man can furnish 2,400 gal. of water for 240 sq. yd. of 6-in. macadam. If wages are 45 ct. per hr., the cost of pumping to a height of 16 ft. (where 10 gal. are used per sq. yd.), is a trifle more than 3 ct. per cu. yd. of macadam.

On ordinary roads, unless there is a very steep pull from the creek or river bed, a sprinkling wagon holding 450 gal. (or 1.9 tons) of water can readily be hauled by a team. The team time required to load the sprinkler from a tank and discharge its contents on the road is ordinarily about 20 min., costing 24 ct. for the 450 gal. when team is \$7.00 per 10-hr. day. With a traveling speed of 2½ miles per hr., the cost of hauling is 56 ct. per tank (450 gal.) per mile of haul from water supply to point of delivery.

Hence, to a fixed cost of 24 ct. per tank (for team item loading and discharging the water), add 56 ct. per tank per mile of haul.

With a haul of 1 mile the cost is, therefore, 80 ct. per tank of 450 gal. If 10 gal. are used per sq. yd. of 6-in. macadam, the cost of hauling water the first mile is, therefore, 2 ct. per sq. yd., or 12 ct. per cu. yd. of compacted macadam; and each subsequent mile costs 8 ct. per cu. yd. of macadam.

It generally happens, however, that when the haul is a mile, or less, a sprinkling wagon is kept going continuously, regardless of the amount of water used. In that case, if wages of team and driver are \$7.00 per 10-hr. day, and interest, depreciation and repairs of the sprinkling wagon are \$1.00 per day, the daily cost of \$8.00 must be divided by the amount of macadam com-

pacted by the roller, or 40 cu. yd., making a cost of 20 ct. per cu. yd., or 3.4 ct. per sq yd. of 6-in. macadam, regardless of how short the haul is

In California, where the hauls for water are apt to be long, it is not unusual to see tank wagons holding 900 gal. or more, hauled by six horses.

Summary of Cost of Macadam. Based upon the foregoing rates of wages, etc., the following summary, Table I, is given:

Table I.—Cost of Macadam.

Item		Per Cu. Yd.
1	1.3 cu. yd. (1.62 tons) coarse stone, f. o. b. cars at $1.50	$1.95
2	0.3 cu. yd. (0.38 tons) screenings, f. o. b. cars at $1.50	.45
3	2 tons (1.6 cu. yd.) freight at $1.00	2.00
4	1.6 cu. yd. loaded into wagons	.26
5	1.6 cu. yd. lost team time loading	.13
6	1.6 cu. yd. hauled (1 mile)	.64
7	1.3 cu. yd. spread by hand	.16
8	0.3 cu. yd. spread by hand	.09
9	Rolling	.50
10	Sprinkling	
11	Foreman	.10
12	Night watchman, water boy, and one-half of timekeeper	.18
13	General supervision, office expense, insurance, etc., at 8 per cent of items 4 to 12, inclusive	.22
	Grand total	$6.88

The cost per cu. yd. relates to a cubic yard of macadam packed in place, and not per cu. yd. of loose stone.

The cost per sq. yd. is for macadam 6 in. thick after rolling, and is, therefore, exactly one-sixth of the cost per cu. yd.

The cost per ton of macadam would be $3.40 for a ton of 2,000 lb. of stone having a specific gravity of 2.7, weighing 4,546 lb. per cu. yd. solid (or 2,500 lb. per cu. yd. loose broken stone having 45 per cent voids) and assuming that the completed macadam weighs 4,000 lb. (2 tons) per cu. yd. of completed macadam, which is equivalent to a macadam having only a little more than 10 per cent voids after rolling and binding. Codrington states, in the Encyclopedia Britannica, that a piece of old macadam contained only 5 per cent voids, as determined by careful weighing.

In considering each item, refer to the previous discussion.

If the stone is quarried near the road, item 3 (freight) will not exist; and item 4 (loading wagons) will be reduced to 3 ct. per cu. yd. of macadam; also item 5 (lost team time) will be reduced.

If the haul is 2 miles, item 6 will be exactly doubled; on the other hand, if the hauling can be done over a macadam road, this cost per mile can be cut in two, and it can be still further reduced if a traction engine is used.

If the coarse stone is spread with a "leveler," as it always should be, item 7 (spreading) will be exactly one-third as much as given; but item 8 will not be affected.

If the subgrade is naturally hard, or has been compacted with a rolling tamper having projected teeth or tampers, item 9 (rolling) may be reduced 30 per cent or more.

If the haul of water for sprinkling is less than a mile, or if the sprinkler is not kept constantly busy, item 10 can be materially reduced.

Item 11 (foreman) is given on the basis of half the foreman's time being charged to the macadam, the other half being charged to grading; and the same being true of the timekeeper's time in item 12.

Item 13 (general supervision, etc.) is rated at 8 per cent of all costs, except the cost of broken stone delivered on cars, for it is here assumed that the stone is purchased.

If wages of laborers and teams are greater than $4.50 and $7.00 per 10-hr. day, the above costs should be increased in direct ratio to the increased wages.

Cost of Scarifying and Resurfacing Macadam

Cost of Scarifying Macadam by Hand.—Mr. Thomas Aitken is authority for the following English data:

When a macadam surface is to be picked, or scarified, by hand, soak the crust with water to soften it, unless it is the intention to screen the old materials. The depth to which the macadam is loosened by picks is usually about 2½ ins. One man will loosen at the following rate per day:

	Sq. yds.
Soft macadam	33
Hard macadam	20
Very hard (steam rolled) macadam	12 to 15

Cost of Scarifying With a Machine.—A scarifier is a heavy harrow for ripping up old macadam preparatory to resurfacing it.

A scarifier is pulled by a roller tractor or truck, and it usually requires two men to operate the scarifier. According to Thomas Aitken, a scarifier with 3 teeth, spaced 6 ins. apart, will break up old macadam to a depth of 4 ins. at the rate of 3,000 sq. yds. per 10-hr. day, if not interrupted by traffic. He gives one record of 650 cu. yds. per hr., scarified to a depth of 3 ins., using a 15-ton roller to pull it. But, allowing for interruptions from traffic that ordinarily occur on a country road, he gives 1,500 to 2,000 sq. yds. per 10-hr. day.

He states that each set of teeth will scarify only 150 sq. yds. before requiring sharpening, and that it costs 30 to 60 cts. to sharpen the set of 3 teeth, at which rate it costs 0.2 to 0.4 ct. per sq. yd. for sharpening the teeth. This would give a cost of $6 to $12 per day for sharpening teeth where 3,000 sq. yds. are scarified daily.

Cost of Shaping Up and Rolling Old Macadam.—

The cost of dressing up 12-ft. wide limestone macadam roads in Putnam County, Indiana, with a steam roller having a scarifier attachment ranged from $10 to $20 per mile. The average cost for the months of May, June, July and August was about $14 per mile. The average total cost per day for the roller for this period, including coal, was $14. The cost of coal per day was $2.80. The above figures are based on the following costs:

Coal	$6 per ton
Roller operator	60 ct. per hour
Helper	50 ct. per hour
Team and driver for hauling coal	70 ct. per hour

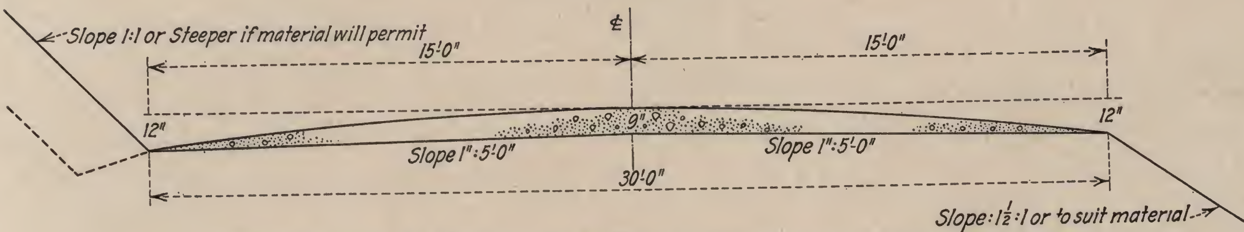
The average number of days operated per month was 24.6, the average number of miles covered during this time being 23.5 or about 0.95 mile per day.

Rate of Scarifying Macadam Road With Scarifier.—In a paper, presented at an annual conference of Ontario Road Superintendents, R. Crawford Muir described the reconstruction of Dundas Street, the chief means of access to Toronto.

The old road was scarified 4 to 6 in. deep for its full length and width, and the loose stones were drawn to the sides to form the shoulders, thus reducing the crown necessary for the new surface.

The scarifier was attached to the side of the roller. This scarifier consisted of 2 picks or teeth and was capable of picking up 800 to 1,200 sq. yd. a day.

Sand-Clay and Topsoil Construction



Standard Sections for Sand-Clay and Topsoil of North Carolina State Highway Department.

TOPSOIL OR NATURAL SAND-CLAY

Specifications of State Highway Commission of North Carolina

1. Description. Upon the subgrade, prepared as hereinbefore specified for "Subgrade," shall be constructed a topsoil or natural sand-clay surface of the cross-section and compacted thickness shown on the plans.

All Borrow Pits will be furnished by the State Highway Commission and must be neatly trimmed and properly drained. Borrow Pits for surfacing which are closer than twenty-five (25) feet to the center line of the road shall not be excavated to a depth lower than the adjacent subgrade.

2. Materials. The surfacing material shall consist of topsoil or sand-clay properly proportioned and mixed by nature, obtained from fields or pits designated and approved by the Engineer. Material from pits containing both sand and clay in separate layers shall be classified as Natural Sand Clay when mixed in the pits. After the source of supply has been stripped the Engineer shall inspect and approve the material before placing it on the subgrade. All material shall be free from weeds, vegetable or other foreign or detrimental matter, and shall contain no stones of greater dimension than one (1) inch. Should any top soil or sand-clay be used containing stones larger than one (1) inch, such stones shall be carefully removed by hand or otherwise, during the process of plowing and harrowing surface material, as hereinafter provided in paragraph 3. Should the Contractor fail to do this, the Engineer may require him to scarify the surface to the depth of three (3) inches, and use a spike tooth harrow to bring all such stones to the surface, and rake them off before final acceptance. Should any such objectionable material be placed on the road, it shall be removed by the Contractor at his expense, unless otherwise permitted by the Engineer.

3. Construction Methods. The topsoil or natural sand-clay shall be evenly spread on the subgrade to such a depth that when compacted, it will have the thickness shown on the plans. Ample allowance for shrinkage must be made at the time material is placed on the road. After sufficient material has been dumped for a section of from five hundred (500) to one thousand (1,000) linear feet of road, it shall be plowed to the full depth of surfacing and spread approximately to the required cross-section and harrowed to secure uniformity. A standard road machine weighing not less than twenty-five hundred (2,500) pounds shall be used to bring the surfacing material to the cross-section shown on the plans, and shall be run over the shoulders of the roadway to bring the same to the required cross-section. The surface part of the roadway shall be harrowed with both disk and tooth harrow until uniform density is secured, after which the roadway shall be brought to the required cross-section and surface grade. The finished roadway shall be maintained as provided in the "Maintenance" paragraph under "General Provisions," "Shaping and Reshaping" to be as hereinafter specified.

4. Shaping and Reshaping. Beginning the day after it is laid and continuing each day for three (3) successive days thereafter the newly laid surface shall be harrowed and reshaped as described above.

The shaping and reshaping of any type of topsoil or natural sand-clay surfacing materials after the first three (3) days shall be done only when the materials are wet and the conditions are such that the loosened surface and shoulder materials will be readily compacted by traffic to form a well-bonded surface.

5. Basis of Payment. Topsoil or Natural Sand-Clay will be paid for at the contract unit price per cubic yard, compacted in place and complete, including drainage for borrow pits and all equipment, tools, labor, material, maintenance, and all incidental work thereto. Clearing and grubbing of pits for surfacing will be paid for at the contract unit prices for "Clearing" and for "Grubbing," and stripping of pits will be paid for at the contract unit price for "Borrow Excavations."

ARTIFICIAL SAND-CLAY

Specifications of State Highway Commission of North Carolina

1. Description. Upon the subgrade, prepared as hereinbefore specified for "Subgrade," shall be constructed an artificial sand-clay surface of the cross-section and compacted thickness shown on the plans.

All Borrow Pits will be furnished by the State Highway Commission and must be neatly trimmed and properly drained. Borrow Pits for surfacing which are closer than twenty-five (25) feet to the center line of the road shall not be excavated to a depth lower than the adjacent subgrade.

2. Materials. The surfacing materials shall consist of sand-clay properly proportioned by placing clay on sand base, or sand on clay base, or placing both sand and clay on subgrade, either one or both of which are obtained from the roadway, fields, or pits designated and approved by the Engineer. After the source of supply has been stripped, the Engineer shall inspect and approve the materials before placing on the subgrade. All materials shall be free from trash, weeds, vegetable or other foreign or detrimental matter, and shall contain no stones of greater dimensions than one (1) inch. Should any objectionable materials be placed upon the road, it shall be removed by the Contractor at his expense.

3. Construction Methods—Clay Base. When the clay in the subgrade has been approved by the Engineer, it shall be plowed to a depth of from four (4) to eight (8) inches, as the Engineer directs, to a width equal to the proposed surfacing and harrowed with a tooth and disk harrow until the loosened clay is thoroughly pulverized. Sand shall then be added to a depth of from three (3) to six (6) inches, as the Engineer directs.

4. Mixing Artificial Sand-Clay. The entire depth and width of the surfacing material shall be twice plowed and harrowed when dry, as follows: The plowing shall begin on the outer edge, the material being turned away from the center and thoroughly harrowed with a cutaway disk harrow until pulverized; plowed again, beginning at the center turning the material forward to the center and thoroughly harrowed with a cutaway disk harrow until pulverized. There shall be as many layers of sand, or clay, or both, added, and to the depth ordered by the Engineer. After each additional layer, if any, has been spread, the plowing and harrowing shall be repeated as above. The first time the surfacing material is thoroughly wet, after being mixed as above specified, the road shall be harrowed with a tooth and disk harrow, until the mixture is puddled, when it shall be shaped by the use of a standard road machine weighing not less than twenty-five hundred (2,500) pounds, to the required cross-section and the surface grade, and maintained as provided in the "Maintenance" paragraph under "General Provisions."

"Shaping and Reshaping" to be as hereinafter specified.

5. Construction Methods—Sand Base. When the sand in the subgrade is approved by the Engineer as suitable to use in the surfacing mixture, enough sand from the subgrade shall be plowed and moved with a road machine to outside the outer edge of the proposed surfacing. The subgrade from which this sand has been removed shall be brought true to subgrade section and a layer of evenly spread clay of from two (2) to four (4) inches deposited thereon, and over this shall be spread with a road machine an evenly distributed layer of sand, from that deposited on the sides, to a depth of from three (3) to six (6) inches as the Engineer directs. This and any succeeding layer shall be mixed, puddled, shaped, and maintained as specified for "Mixing Artificial Sand-Clay."

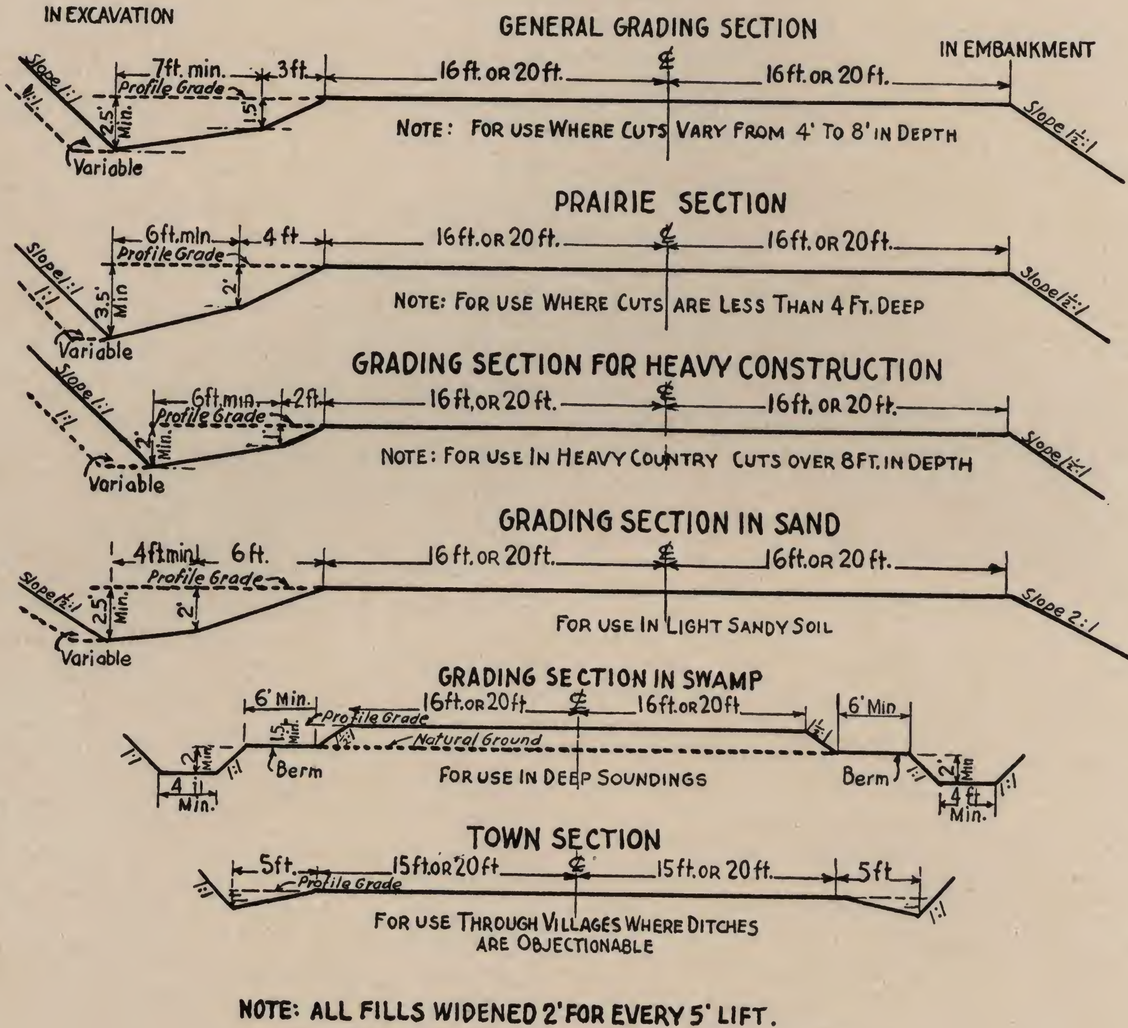
6. Construction Methods—Sand or Clay Base. Where neither sand nor clay in the subgrade is, in the judgment of the Engineer, suitable for use in the mixture, clay shall be deposited and evenly spread in a layer of from two (2) to four (4) inches, as the Engineer may direct. On this shall be placed an evenly spread layer of sand from three (3) to six (6) inches, as the Engineer may direct. The two layers and any succeeding layers shall be mixed, puddled, shaped, and maintained as specified herein for "Mixing Artificial Sand-Clay."

7. Shaping and Reshaping. Beginning the day after it is laid and continuing each day for three (3) successive days thereafter the newly laid surface shall be harrowed and reshaped as described above.

The shaping and reshaping of any type of topsoil, natural or artificial sand-clay surfacing materials after the first three (3) days shall be done only when the materials are wet and the conditions are such that the loosened surface and shoulder materials will be readily compacted by traffic to form a well-bonded surface.

8. Basis of Payment. Artificial sand-clay will be paid for at the contract unit price per cubic yard compacted in place and complete, including drainage for borrow pits and all equipment, tools, labor, material, maintenance, and all incidental work thereto. Clearing and grubbing of pits for surfacing will be paid for at the contract unit prices for "Clearing" and for "Grubbing," and stripping of pits will be paid for at the contract unit price for "Borrow Excavation."

Earth Roads



Standard Grading Sections, Minnesota State Highway Department.

Grading

Standard Specifications Minnesota State Highway Department

CLEARING

Description: Clearing shall consist of the removal or burning of all timber, brush, stumps, rubbish, or other obstructions from within the limits of any part or of the entire right-of-way, also from such areas as may be required for off-take ditches, channel changes, borrow pits and etc.

Method of Clearing: Trees and brush must not be thrown on adjacent lands, but must be disposed of within the limits of the clearing. Trees unavoidably falling outside of the specified limits must be cut up, removed to within the clearing and disposed of.

In clearing the highway, all merchantable timber which it may be necessary to cut, and all other property of value shall be piled on skid-ways in close piles outside of the highway, unless otherwise directed. All timber belongs to the property owner or the party of the first part.

Such material as is not removed shall be piled and burned on the highway in such manner as not to injure any trees or merchantable timber on the right-of-way or abutting property.

In clearing, all brush must be cut even with the ground surface; choice trees which are not in the way of construction or which will not damage the road shall be carefully preserved.

All trees and stumps shall be cut within 6 in. of the ground on all portions of the right-of-way which are to be covered with an embankment of 3 ft. or more.

All clearing must be completed in advance of the grading or ditching as directed by the Engineer.

Basis of Payment. The unit price bid for clearing shall include all of the foregoing work and the furnishing of all equipment, tools and labor incidental thereto. The plans will indicate the stations between which each of the following units shall be used:

(a) Acre as unit. When an acre is specified as the unit, the number of acres shall be determined from measurements taken by the Engineer of the areas on which clearing is actually performed.

(b) Tree as unit. When a tree is specified as the unit, the number of trees will be determined by the Engineer by actual count of all trees of four (4) inches or more in diameter which are cut by the Contractor. Smaller trees and brush shall be cleared in conjunction with the clearing of the larger trees for which no additional payment will be allowed.

(c) Clearing brush. Any clearing required which is not covered under (a) and (b) shall be performed by the contractor under his bid price for excavation.

GRUBBING

Description: Grubbing shall consist of the excavation and removal of all roots, stumps, stubs, grubs, submerged logs, etc., from within the limits of any part of the entire right-of-way, also from such areas as may be required for off-take ditches, channel changes, borrow pits, and etc.

Method of Grubbing: In the operation of grubbing, all roots, stumps, stubs, grubs, submerged logs, etc., shall be excavated and removed to a depth of not less than one (1) foot below the natural surface of the ground. Excavated material shall be piled and burned. Grubbed material shall be piled and burned. Grubbing must be completed at least 1,000 ft. in advance of the grading or ditching unless some special agreement is obtained.

Basis of Payment: The unit price bid for grubbing shall include all of the foregoing work, which price shall include all equipment, explosives, tools, labor, and work incidental thereto.

The plans will indicate the stations between which each of the following units shall be used:

(a) Acre as unit: When an acre is specified as the unit, the number of acres shall be determined from measurements taken by the Engineer of the areas on which grubbing is actually performed. The minimum amount of grubbing that shall be measured shall be one square rod.

(b) Tree as unit: When a tree is specified as the unit, the number of trees will be determined by the Engineer by actual count of all trees of four (4) inches or more in diameter which are grubbed by the Contractor. Smaller trees and brush shall be grubbed in conjunction with the grubbing of the larger trees for which no additional payment will be allowed.

EXCAVATION

(Other Than Hand Ditching)

9. Description: Excavation shall include the removal and satisfactory disposal of all material taken from within the limits of the work contracted for (or from a borrow pit) which is necessary for the construction and preparation of the roadbed, embankment, subgrade, slopes, inter-sections, approaches, private entrances, etc., also side ditches and off-take ditches and waterways which may be dug with teams and ordinary road building equipment as indicated and directed.

10. Classification of Materials: Excavation shall include all materials of whatever nature encountered. The classification of material will be made by the Engineer as the work progresses, and the classification determined upon by the Engineer for the work completed during each month will be included in the current monthly estimate. If classification thus allowed by the Engineer is not protected by the Contractor in writing within fifteen (15) days after the date of payment of each estimate, the Contractor thereby waives his right to any claim to any change in classifications on the work involved in such estimate.

Classification of excavation material shall be on the following basis:

Earth shall include all sand, clay, loam, gravel, and other materials of every description as found which are not included in the following classification for loose and solid rock:

Loose rock shall include all slate, shale, or other rock which can be quarried or loosened with a pick and bar without blasting, even though the Contractor may resort to blasting to facilitate the work; also all detached rock or boulders measuring not less than one-half (½) cubic foot nor more than one-half (½) cubic yard each.

Solid rock shall include all rock in ledge formation, also detached rock or boulders measuring not less than one-half (½) cubic yard each, but shall not include shale, indurated clay, hard pan or scattered boulders of less than one-half (½) cubic yard each.

Overbreak: Overbreak in solid rock cuts is that material which is removed outside the authorized slope lines. Overbreak will not be estimated nor paid for unless in the judgment of the Engineer the causes of such overbreak were beyond the control of the Contractor, and not preventable by the exercise of reasonable care and diligence. If overbreak is allowed it will be classified in accordance with its condition at the time of removal, regardless of the prior condition of such overbreak material.

11. Construction Methods: Excavation shall be made in all cases to the required alignment, grade and cross-section. All suitable materials removed from the excavation shall be used so far as practicable in the formation of the embankment, the materials being deposited in such a manner that the best available finishing material is placed in the upper six inches of the subgrade. Any extra overhaul, which this provision may necessitate, shall be agreed upon by the Engineer and Contractor at the time the work is done. Excess material shall be used in uniformly widening the fills or in raising the grade line where desirable to improve the profile or where necessary to provide for future settlement. No borrowing or wasting will be permitted except upon written orders of the Engineer. In case the distribution of excess material, or the operation of obtaining the additional material required results in any excess cost to the Contractor, he is to be paid for such excess cost.

In solid rock cuts the road bed shall be excavated at least 6 inches below grade and back-filled to grade with suitable material. The Contractor will be paid for 12 inches of excavation below grade between shoulder slope lines and for such backfill as is required.

Where the plans provide side and off-take ditches in a swamp, filling will not be permitted previous to the completion of the ditching.

All side slopes on old embankments which are to be widened shall be broken by horizontal furrows parallel to the center line of the roadway and not more than two (2) feet apart, measured along the slopes, before any material is placed thereon.

Filling against bridges or over culverts must be made with care and in such manner as not to move or strain the structure. In case of any damage being done by such work, the Contractor will be charged with repairing the structure unless such filling is made under the direct supervision of the Engineer.

Trestles will not be allowed in embankments unless they are placed outside of the shoulder line. In case trestles are constructed outside of the shoulder line all timbers shall be removed to a depth of 2 feet below the embankment slope.

No logs, stumps or plank will be allowed in embankment; sod, vegetable matter, peat or muskeg material, if placed therein, shall only be permitted on new work, except as hereinafter provided, and then uniformly pulverized and distributed over the base of the embankment. The use of such materials in back filling old ditches, or shouldering within twelve (12) feet of the center line around old core, will not be permitted. In no instance will sod be placed within twelve (12) inches of the subgrade. Sod, vegetable matter, peat or muskeg material when wasted must be spread uniformly as directed by the Engineer.

Stone placed or left under embankment shall be at least as much below the surface of the subgrade as the height of such stone is above the natural surface of the ground.

All stone not placed in embankment or used for rip-rap shall be placed in neat and uniform piles at intervals of not less than 500 feet unless directed otherwise.

Sufficient hand work shall be performed on the slopes of the cuts and fills, so that such slopes will be left in a neat and workmanlike condition and true to lines given. On shallow shovel cuts this will require the removal of the ridge which a shovel ordinarily leaves along the banks of such shovel work. In deep shovel cuts this will require such hand work as may be necessary to maintain approximately the designated slope on the upper face of the cut and produce a back slope free from humps and hollows. Hand trimming of the back slope will not be required where a neat uniform face corresponding to the designated section is obtained.

The installation of all side culverts, construction of all cross roads and farm entrances, trimming of shoulders to line and finishing all subgrade and ditches to proper alignment and cross section, shall be required to constitute a completed road and this work shall follow the rough grading closely.

Maintenance of Highway: The Contractor shall furnish and have available at all times a 12 foot blade grader with sufficient power to blade and maintain the road surface.

After one or more miles of completed highway has had sufficient blading and satisfactory maintenance for a period of thirty days, it will be accepted by the Engineer. Any further maintenance of such sections shall thereafter be paid for on a force account basis. In the course of maintenance blading it is desirable to keep the middle of the road crowned sufficiently to drain at all times. The crown shall not exceed three-tenths of a foot unless additional crown is definitely ordered by the Engineer.

Requirements of this section shall not prevent the payment of any partial estimate providing weather conditions make the finish of this work impossible.

13. Basis of Payment. The contract price per cubic yard for excavation shall include all the foregoing work and the furnishing of all equipment, tools and labor incidental thereto, providing the excavated material is not hauled beyond the free haul limit of five hundred (500) feet. For material hauled more than five hundred (500) feet measured along the center line, the Contractor shall be paid in addition an overhaul price per cubic yard for such overhaul computed as follows:

The limits of free haul shall be determined by fixing on the profile two points: One on each side of the neutral grade point, one in excavation and the other in embankment, such that the distance between them, measured along the center line of the road, shall equal the specified free haul limit and the included quantities of excavation and embankment balance. All haul on material beyond this free haul limit shall be estimated and paid for on the basis of the following methods of computation, viz: All material within the limit of this free haul shall be eliminated from further consideration. The distance between the center of gravity of the remaining mass of excavation and center of gravity of the resulting embankment, measured along the center line of the road, less the limit of free haul as above specified, shall be length of overhaul; the compensation to be rendered therefor shall be determined by multiplying the yardage in the remaining mass, as above described, by the length of the overhaul. Payment of the same shall be units of one cubic yard hauled one hundred (100) feet. In the case of excavation obtained from borrow pits the

haul shall be measured along the shortest practical line of haul which shall be agreed upon by the Contractor and the Engineer before the borrow excavation is made.

The excavation quantities will be determined by cross sections taken prior to the opening of cuts and again upon their completion. The classification of material will be made by the Engineer as the work progresses, and the classification determined upon by the Engineer for the work completed during each month will be included in the current monthly estimate. If classification thus allowed by the Engineer is not protested by the Contractor in writing within fifteen (15) days after the date of payment of such estimate, the Contractor thereby waives his right to any claim to any change in classifications on the work involved in such estimate.

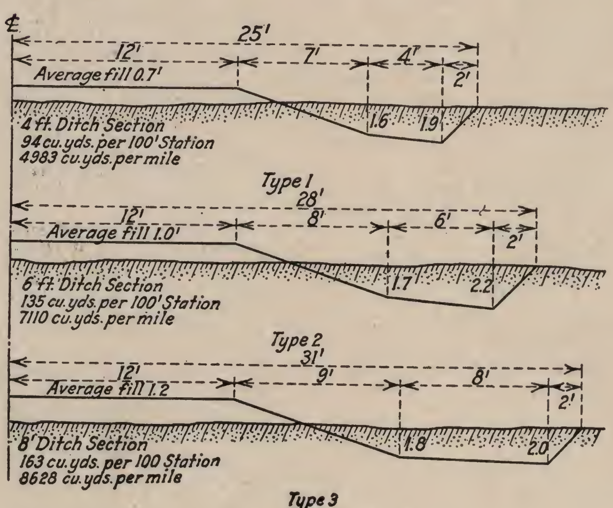
When a representative of the Engineer is not stationed on the job continuously, the Contractor shall, in order to claim classification of material, as loose rock or solid rock, notify the Engineer prior to or during the excavation of such material, so that proper measurements may be taken to determine the quantity of material under each classification. Unless such notice is given by the Contractor, and proper opportunity is given the Engineer to obtain such measurements, no claim for special classification will be allowed.

Blade and Cast in Work

Standard Specifications South Dakota Highway Commission.

Description. Blade and cast in work shall consist of forming side ditches and shoving the material therefrom and properly placing it in embankment by means of a blade grader or otherwise, and forming the entire roadway in strict accordance with the alignment, cross-section and profile grade shown on the approved plans, no hauling is included in this work.

When Specified. Blade and cast in work will be specified where the ground line and grade line, as shown on profile, are parallel or symmetrical and it is practicable to form side ditches, which will drain, and place the material excavated therefrom in embankment by means of a blade or elevated grader. Blade and cast in work will not ordinarily be specified where the continuous length of such work



Standard Blade Grade Sections, South Dakota State Highway Commission.

is less than 2,000 feet unless several distances of shorter length totaling 2,000 feet or more are separated by short distances requiring hauled material. The work in such intermediate sections (and all earth work) involving hauling shall be paid for in accordance with Articles 89 to 107 inclusive of the Standard Specifications.

Method of Work. The work shall be staked out as provided in Article 66 of the Specifications, save that instead of at random distances from the center line the usual survey stakes shall be placed on the line of the proposed finished back slope cut. Grade stakes, giving profile grade as shown on approved plans, shall be set at points not further than 100 feet apart along all the work. All weeds and rank growth between these stakes shall be cut and burned. In marking out, a light cut shall be made running true to these stakes. The full width of the ditch section shall then be stripped of all sod, which shall be well pulverized and spread across the area under embankment, or wasted as directed by the Engineer. The blade cuts should then be stepped in and down from the first cut and following the general line of the required finished back slope, leaving the back slope to a finished plane. Ditches must be left free from pockets or high points that would cause standing water and the blading must be continued until the required section is formed and the roadway surface is compacted, smooth and free from all clods, sod or stone. A disc harrow shall be used, when ordered by the Engineer, to pulverize clods, or sod.

Widening and Shaping of the Road. Where the road under construction has previously been graded and the ditches are not cut the required distance from the center, the following method will be used. After all weeds have been removed, the sod shall be stripped from the area between the stakes and deposited in the bottom of the old ditches. Where it is evident that the old ditch is not deep enough to permit of depositing the sod and covering same with earth, the sod shall be plowed and disc harrowed until the same is thoroughly pulverized.

Side Hill Work. Blade and cast in work may be designated where the transverse slope is not greater than twelve to one. The first or marking out cut will be made to stakes set out to conform to the approved section for side hill construction and to the profile grade shown on the plans. All sod will be stripped for the full width of the excavation and bladed to the outer edge of embankment. A light cut may be made marking out the toe of the slope of the embankment but no other cutting will be allowed on the low side.

Basis of Payment. Blade and cast in work will be estimated and paid for by the lineal foot at the price bid, which payment shall be in full for all work and the furnishing of all tools, equipment, labor and materials necessary. No work shall be paid for which is not finished in accordance with the alignment, profile, grade and cross-section shown on the approved plans.

Borrow. The standard specifications of the North Carolina State Highway Commission contain the following clause regarding borrow:

Borrow. When sufficient quantities of suitable materials are not available from the roadway excavation to properly form the embankments, subgrade, and shoulders of the road, such additional material must be obtained from borrow pits furnished by the State Highway Commission and located by the Engineer. Where borrow pits are necessary, the Engineer in locating the same shall give preference to the widening of cuts on the inside of curves. No portion of any borrow pit, except in case of widened cuts, shall be located closer than fifty (50) feet from the edge of the right of way line unless shown on plans or otherwise permitted in writing by the Engineer.

If the Contractor places more "Borrow" than is required, causing a waste of "Excavation" the amount of such waste shall be deducted from the "Borrow" as measured in the "Borrow Pit."

Borrow shall be computed by the method of average end areas. Borrow Pits shall be staked out and cross-sectioned before the Contractor begins work therein. No payment whatever will be allowed the Contractor for any material excavated from Borrow Pits, or elsewhere, prior to the staking out and cross-sectioning of the work by the Engineer. All Borrow Pits shall be excavated, neatly trimmed, and left in such shape as to admit of reasonably accurate measurement after the excavation of the same is completed. Embankment measurement will not be allowed except by written permission of the Engineer. They shall also be sufficiently drained so that no water will collect or stand therein.

Basis of Payment. All borrow will be paid for at the contract unit price per cubic yard for "Borrow" which shall include the removal and placing of all material in its final position in the highway, and the use of all equipment, tools, labor and work incidental thereto, except that clearing and grubbing of Borrow Pits will be paid for at the contract unit prices per acre for "Clearing" and for "Grubbing."

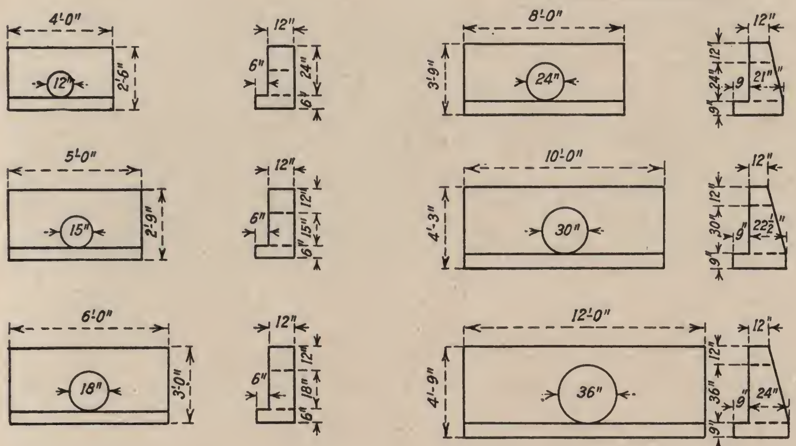
Excavation Classification.—The new standard specifications for road and bridge construction of the Division of Highways of the Illinois State Department of Public Works and Buildings, contains the following classifications for excavation:

Class A Excavation (Earth). This classification shall include clay, sand, loam, gravel, and all hard material that can, in the opinion of the Engineer, be reasonably plowed all earthy matter or earth containing loose stones or boulders intermixed; all other material which does not come under Class B or Class C Excavation.

Class B Excavation (Intermediate). This classification shall include all stone and detached rock measuring less than one-half (½) cubic yard in volume; all slate, shale, conglomerate, and like materials, soft or loose enough to be removed with heavy machinery without blasting, even though blasting may be resorted to in order to expedite the work.

Class C Excavation (Solid Rock). This classification shall include all boulders measuring one-half (½) cubic yard and upwards all solid or hard ledge rock in removing which it is necessary to resort to continuous drilling and blasting.

Pipe Culverts

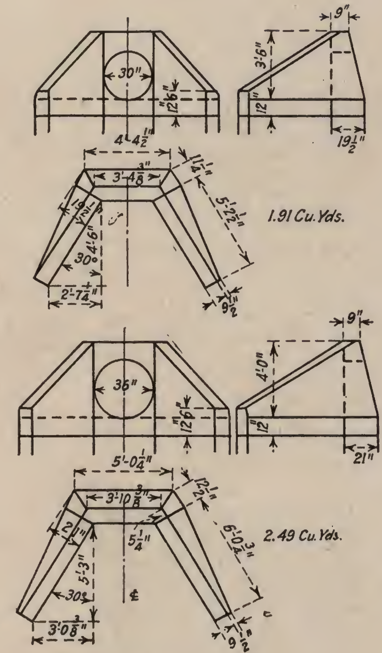


Quantities for 1 Headwall

12" Pipe	*0.38 Cu. Yds.*
15" Pipe	*0.51 Cu. Yds*
18" Pipe	*0.66 Cu. Yds.*

Quantities for 1 Headwall

24" Pipe	*1.60 cu. yds.*
30" Pipe	*2.31 cu. yds.*
36" Pipe	*3.15 cu. yds.*



Standard Headwalls for Pipe Culverts of Virginia State Highway Department

WEIGHTS OF RIVETED STEEL, CORRUGATED METAL AND CONCRETE PIPE CULVERTS

From Standards Mississippi State Highway Department

RIVETED STEEL

Inside diam. in.	Area of opening sq. ft.	Thickness of shell in.	Rivets Min. diam. in.	Rivets Max. pitch in.	Weight per lin. ft. lbs.
12	0.8	....	....	....	......
15	1.2	....	....	....	......
18	1.8	3/16	½	4	40
24	3.1	1/4	½	5	70
30	4.9	1/4	½	5	85
36	7.1	5/16	⅝	6	130

CORRUGATED METAL

Thickness of metal Gauge	Thickness of metal in.	Weight per lin. ft. lbs.
16	1/16	10
16	1/16	12¼
16	1/16	15½
14	5/64	24
14	5/64	30
12	7/64	36

CONCRETE*

Thickness of shell in.	Reinforcement Desired Wght. per sq. ft.	Reinforcement For example A. S. & W. Co's. Style	Weight per lin ft. lbs.	Inside diam. in.
2	.4 lb. in 1 layer	No. 3= .44 lb. per sq. ft.	85	12
2¼	.5 lb. in 1 layer	No. 2= .51 lb. per sq. ft.	120	15
2½	.6 lb. in 2 layer	No. 5= .63 lb. per sq. ft.	160	18
3	.8 lb. in 2 layer	No. 4= .80 lb. per sq. ft.	260	24
3½	1.0 lb. in 2 layer	No. 25=1.01 lb. per sq. ft.	365	30
4	1.2 lb. in 2 layer	No. 42=1.20 lb. per sq. ft.	500	36

*Usual length of section is 4 ft. Butt joints, tongue and groove, taper or socket joints may be used. Weights given do not include weights of joints.

APPROXIMATE DISCHARGE CAPACITY FOR CULVERTS

From Standards for Field and Office Use of Montana State Highway Commission

SMOOTH PIPE

Velocity in Feet Per Second, Discharge in Second Feet

Slope in ft. per 100 ft.	12 in. Vel.	12 in. Dis.	15 in. Vel.	15 in. Dis.	18 in. Vel.	18 in. Dis.	24 in. Vel.	24 in. Dis.	30 in. Vel.	30 in. Dis.	36 in. Vel.	36 in. Dis.
0.5	3.7	3	4.4	5	5.0	9	6.2	19	7.2	35	8.7	57
1.0	5.2	4	6.3	8	7.1	13	8.7	27	10.3	50	11.7	82
2.0	7.5	6	8.8	11	10.2	18	12.4	39	14.5	71	16.3	115
3.0	9.1	7	10.9	13	12.5	22	15.1	47	17.8	87	20.1	142
4.0	10.5	8	12.5	15	14.4	25	17.5	55	20.5	101	23.2	164
5.0	11.8	9	14.0	17	16.0	28	19.6	62	23.0	113	26.0	184
6.0	12.9	10	15.3	19	17.5	31	21.5	68	25.2	124	28.4	201
Area sq. ft.	0.7854		1.2272		1.767		3.142		4.909		7.069	
Value of R	0.250		0.312		0.375		0.500		0.625		0.750	

CAST IRON PIPE

From Standards for Field and Office Practice Kentucky State Department of Roads

Inside Diameter in.	Cast Iron Water Pipe Class "A" Thickness in.	Cast Iron Water Pipe Class "A" Wt. per ft. lbs.	Cast Iron Culvert Pipe Thickness in.	Cast Iron Culvert Pipe Wt. per ft. lbs.
12	.54	72.5	7/16	50
14	.57	89.6	7/16	60
16	.60	108.3	½	80
18	.64	129.2	½	90
20	.67	150.0	½	120
24	.76	204.2	9/16	160
30	.88	291.7	11/16	220

Length of section not less than 3 ft. nor more than 12 ft.

CONCRETE BOXES

Slope in feet per 100 ft.	2 ft.x2 ft. V	2 ft.x2 ft. D	2 ft.x4 ft. V	2 ft.x4 ft. D	3 ft.x4 ft. V	3 ft.x4 ft. D	4 ft.x4 ft. V	4 ft.x4 ft. D	4 ft.x5 ft. V	4 ft.x5 ft. D	4 ft.x6 ft. V	4 ft.x6 ft. D	6 ft.x6 ft. V	6 ft.x6 ft. D	6 ft.x8 ft. V	6 ft.x8 ft. D	10 ft.x10 ft. V	10 ft.x10 ft. D	10 ft.x12 ft. V	10 ft.x12 ft. D
0.5	7.6	30	9.9	79	11.1	133	11.7	187	13.1	262	14.0	336	15.5	558	17.3	830	21.2	2120	22.7	2724
1.0	10.7	43	14.1	113	15.8	190	16.8	269	18.5	370	19.8	475	21.9	788	24.5	1176	29.9	2990	32.1	3852
2.0	15.2	61	19.9	159	22.3	268	23.8	381	26.1	522	27.9	670	31.0	1116	34.6	1661	42.3	4230	45.5	5460
3.0	18.6	74	24.4	195	27.3	328	29.2	467	32.0	640	34.2	821	38.0	1368	42.3	2030	51.8	5180	55.7	6684
4.0	21.5	86	28.2	226	31.5	378	33.7	539	37.0	740	39.6	950	43.9	1580	49.0	2352	59.7	5970	64.2	7704
5.0	23.9	96	31.3	250	35.3	424	37.7	603	41.4	828	44.1	1058	49.0	1764	54.7	2626	66.3	6630	71.9	8628
6.0	26.2	105	34.5	276	38.6	463	41.3	661	45.3	906	48.3	1159	53.6	1930	60.0	2880	73.1	7310	78.9	9468
Area Sq. Ft.	4.0		8.0		12.0		16.0		20.0		24.0		36.0		48.0		100.0		120.0	
Value of R	0.67		1.00		1.20		1.33		1.54		1.71		2.00		2.40		3.33		3.75	

Computed from Chezy Formula $V=C.\sqrt{RS}$ $D=VA$ $R=A/P$=Hydraulic Radius. P=Wetted perimeter. N=Coeff of roughness=0.011.

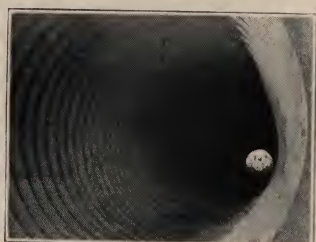
ARMCO CULVERT MANUFACTURERS ASSOCIATION

Middletown, Ohio

Manufacturers of Armco Pipe and Drainage Products

DISTRIBUTING MANUFACTURERS

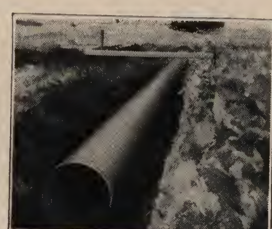
Bark River Bridge & Culvert Co., Eau Claire, Wis.; Bark River, Mich.
The Boardman Company, Oklahoma City, Okla.
The Burnham Mfg. Company. Plants at: Woods Cross, Utah; Boise, Idaho
California Corrugated Culvert Co., West Berkeley, Calif.; Los Angeles
Canada Ingot Iron Co., Ltd., Guelph, Calgary, Sherbrooke, Edmonton, Winnipeg, Vancouver
Corrugated Culvert Company, Moberly, Mo.
Dixie Culvert Manufacturing Co., Little Rock, Ark.
The Dixie Culvert & Metal Co., Jacksonville, Fla.; Atlanta, Ga.
The R. Hardesty Manufacturing Co., Denver, Colo.; Missoula, Mont.
Highway Products & Manufacturing Co., Inc., Elmira, New York
Independence Corrugated Culvert Co., Independence, Ia.; Mason City
Ingot Iron Railway Products Company, Middletown, Ohio
Iowa Pure Iron Company, Des Moines, Iowa
Kentucky Culvert Mfg. Co., Louisville, Ky.
Louisiana Corrugated Culvert Co., Baton Rouge, La.
Lyle Culvert & Road Equipment Co., Minneapolis, Minn.
Maryland Culvert & Metal Company, Baltimore, Md.
Nebraska Culvert & Mfg. Co., Wahoo, Nebr.
New England Metal Culvert Company, Palmer, Mass.; Boston, Mass.; Portland, Me.
Northwestern Sheet & Iron Works, Wahpeton, N. D.
The Ohio Corrugated Culvert Company, Middletown, Ohio
The W. Q. O'Neall Company, Crawfordsville, Ind.
Pure Iron Culvert & Mfg. Co., Portland, Ore.
The Road Supply & Metal Co., Topeka, Kan.
Sioux Falls Metal Culvert Co., Sioux Falls, S. D.
Spokane Culvert & Tank Co., Spokane, Wash.
The Tennessee Metal Culvert Co., Nashville, Tenn.
U. S. Bridge & Culvert Co., Bay City, Mich.
Virginia Culvert Corporation, Roanoke, Va.
Western Metal Manufacturing Co., Houston, El Paso, Dallas, Tex.



Armco Corrugated Pipe: A pipe of corrugated, flexible design made from a metal of the highest purity and unvarying uniformity—Armco Ingot Iron (99.84% pure). The severe test of actual service, confirmed by evidence from every state and under every known condition of load and climate, has proved that for strength and durability Armco corrugated pipe has no superior.

Its immediate availability, quick and simple installation, safety under the impact of traffic, and freedom from repair and upkeep expense, have established it as a most advantageous and economical product for the highway official.

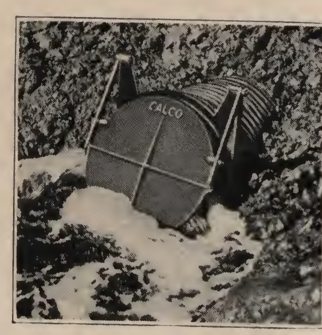
Its major uses are for culverts and bridges under highways, enclosure and elimination of open streams, and undercrossings for cattle passes or other purposes. Our bulletin H-31 describes these and other practical solutions of the road builder's problems. Send for it today.



Armco Perforated Pipe: This product was developed to meet a demand for a drain of greater strength and dependability than had previously been available. It is Armco corrugated pipe with perforations in the valley of each corrugation for a portion of the circumference and has all the advantages of this pipe plus a high subdrainage efficiency.

Its most important uses are: subdrainage under pavements, drainage behind retaining walls and abutments, mosquito elimination, drainage of parks, athletic fields and landing fields, and the prevention of landslides. Write for our bulletin H-30, which gives more information about this product.

New Standard Armco Fittings: The fittings here shown place at the immediate disposal of public officials a high quality of drain pipe connections and thus obviate the need for special designs for each job. The Armco fittings are sturdy in construction and workmanlike in appearance. They include elbows, bends, tees, wyes, crosses, increasers and reducers, and are made to fit standard sizes of Armco pipe, to which they are readily and quickly attached.



Drainage Gates: Calco automatic drainage gates have been especially designed to prevent reversal of flow through drainage outlets. They are made of cast iron, are sensitive to the slightest change of pressure and are durable and efficient. They effectively prevent backflow.

Typical uses are: reclaiming overflowed land, draining swamps, building up low-land through silt control, abating the mosquito nuisance, protecting storm sewer outlets, assisting in local flood prevention, maintaining water levels in streams or lakes.

Continued on Next Page

Stream Enclosures: Open ditches and small streams paralleling a road are a source of danger to traffic. A guard fence provides partial protection but also acts as a restriction. Frequently the value of adjoining land is depressed because of the lack of development. The solution is found in enclosing such streams in large diameter Armco pipe and then filling over them.

Frequently the increased value of the land is more than sufficient to offset the cost of the improvement. In addition, safety of the highway is increased, and any future widening can easily be accomplished.

Under-Crossings: It is becoming increasingly dangerous to drive livestock along or across main traveled highways. Frequently, however, when a farm is situated on both sides of the road, cattle must be driven across at least twice a day.

The logical solution is to install an under-crossing. This consists of a large diameter Armco pipe, which in some instances can serve also as a drainage structure. Installation can be made either by open trenching across the road, or by the Armco jacking method without disturbing traffic.

Culvert Bridges: Countless installations have proved that traffic is safe on Armco culvert bridges of even the largest diameters. This proof in actual service has been supplemented by an exhaustive investigation by the A. R. E. A., which shows conclusively that large diameter Armco culverts can resist safely the weight of the heaviest loads of fill and traffic.

Summary of Their Advantages Over Small Bridges:

1. Water-carrying capacity suited to the requirements of the stream—ample but not excessive.
2. Traffic safety unimpaired by hidden structural defects.
3. Cost of construction low. Cost of maintenance negligible.
4. Roadway and shoulder space free and unobstructed.
5. Culvert pipe immediately available. Installation quickly made.
6. No traffic interruption because of construction or maintenance.
7. Future extensions easily made.
8. Movability without loss of service value.

Armco Jacking Method: It often becomes necessary to provide new openings under highways for new or additional drainage lines. This can be done by the Armco jacking method by which a pipe is jacked through the embankment underneath. This process requires a pipe of unusual strength and flexibility—a pipe which will be continuous from end to end and will maintain its alignment and grade while being jacked. Wherever this problem has arisen a satisfactory solution for it has been found in Armco corrugated pipe. Ask for our bulletin R-23 describing this method of installation.

Advantages of Armco Jacking Method:

1. Roadbed is undisturbed.
2. No work is done at track or pavement level.
3. No falsework required.
4. No slow orders or detours.
5. Safety of traffic unimpaired.
6. Construction period cut to one-half or one-third.
7. No skilled labor required.
8. No settlement of roadbed after construction.
9. Installation costs reduced one-half to two-thirds.

AMERICAN PRESSED STEEL COMPANY

Philadelphia, Pa.

Manufacturers of Neverslip Traffic Plates

Agents and Warehouse Stocks in Principal Cities

NEVERSLIP
TRAFFIC PLATES
FOR BRIDGES

Products: "NEVERSLIP" ROLLED STEEL TRAFFIC PLATES AND FLOOR PLATES. DIAMOND OR RIBBED PATTERN.

The placing of two lanes of Traffic plates about 24" wide, spaced about the normal gauge of vehicles, for the entire length of the bridge directly over the worn planking, eliminates reflooring and strengthens the bridge roadway. For a two-way bridge, these are laid with one on each side and one in the center. By this application the vibration is overcome as well as the chatter which is so common and the constant annoyance of rising spikes, so dangerous and detrimental to automobile traffic, is eliminated.

Anti-skid chains tear wood and a concentrated load frequently breaks the planks between supports, while *Neverslip* Traffic Plates will give a durable non-slipping surface and distribute the heavy loads over a greater area.

NEVERSLIP TRAFFIC STRIP

SPECIFICATIONS

Thickness: The thickness is measured through the body of the plate exclusive of the Raised Diamond.

We recommend 3/16" plates, weighing approximately 8¾ lbs. to the square foot. For extraordinary conditions ¼" (11¼ lbs) and 5/16 (13¾ lbs.) plates are used.

Width: For One-Way Traffic Bridges—two lanes 20" to 24" wide each.

For Two-Way Traffic Bridges—four lanes 20" to 24" wide each or two lanes 20" to 24" wide each and one middle lane 30" to 42" wide which can be used by traffic in either direction.

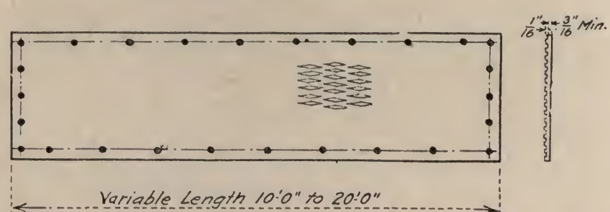
Length: Plates approximately 12' long serve to greatest advantage and are conveniently handled.

Fabrication: Punched every 12" on both edges of the long dimension and every 4" across the ends or width of the plate. The above is approximate, as the holes are staggered and placed between the raised diamonds so that the heads of the lag screws will hold the plate securely.

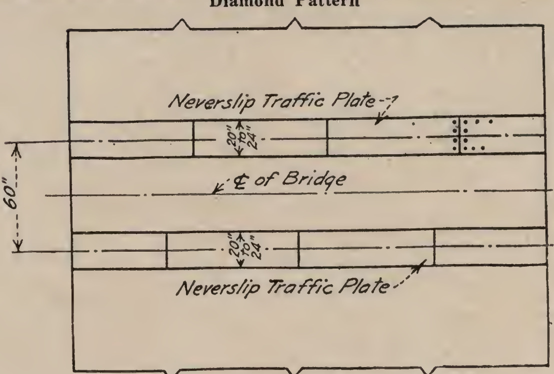
Lag Screws (Galvanized): Hexagon head lag screws ⅜" by 3" or depending upon the thickness of the planking. Carriage bolts with locknuts and washers are occasionally used.

The surface of the planking over which the plates are to be placed should be adzed where the flooring is not smooth due to variation in the thickness of the timber, and the end plates should be turned down and fastened to the curtain board in the absence of an angle.

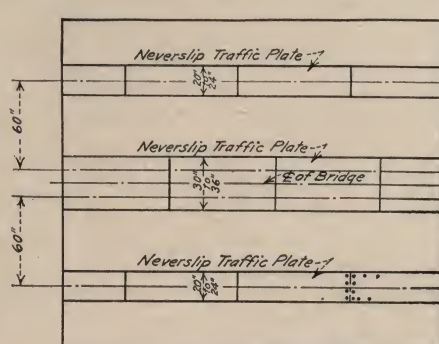
Diamond Pattern



Sketch of Neverslip Traffic Plate Showing Holes for Lag Screws.



One Way Traffic Plan



Two Way Traffic Plan

ALAN WOOD IRON AND STEEL CO.

Widener Building, Philadelphia, Pa.

"A. W." Diamond Pattern Rolled Steel Traffic Treads

DISTRICT OFFICES

New York, 50 Church Street.
Boston, 141 Milk Street.
Dallas, Santa Fe Building.
Seattle, Dexter Horton Building.
Los Angeles, San Fernando Building.
San Francisco, 444 Market Street.

Products: "A. W." Diamond Pattern Rolled Steel Traffic Treads for Bridge Floors.

Also — "Swede" Pig Iron — Billets, Blooms, Slabs—"A. W." Sheared Plates—"A. W." Diamond and Ribbed Pattern Rolled Steel Floor Plates.

"A. W." Diamond Pattern Rolled Steel Traffic Treads applied on wooden-floor bridges eliminate constant replanking costs, reduce impact load to a minimum, provide an easy driving surface, and lower maintenance charges.

Rattle and Chatter Eliminated: The installation of "A. W." Traffic Treads will eliminate vibration, and prevent the working up of nails and spikes from the floor, thus removing a source of constant danger to pneumatic-tired vehicles. At the same time the rattle and chatter of loose planks disappear.

"A. W." Traffic Treads are laid directly over the lines of traffic wear on old and worn floors, being fastened thereto by square head lag screws, or other fasteners if preferred. On new bridge floors, the traffic lane is first determined and the treads laid accordingly. They are easily applied to all types of wooden floors on both large or small bridges at a comparatively low installation cost.

Engineering Service: Our engineering department will gladly co-operate with highway engineers and officials in the solution of bridge maintenance problems.

SPECIFICATIONS

Thickness: ⅛", 3/16", ¼" or 5/16" measured through body of tread exclusive of design.

Width: From 18" to 30", or wider, depending on local conditions of bridge.

Length: From 10' to 21'6", as required.

Weight: 3/16" approx. 8.75 lbs. per sq. ft.; ¼" approx. 11.25 lb. per sq. ft. Other thicknesses on application.

Fabrication: Punched approximately every 12½" on both edges indicated as length dimension, and approximately every 5⅝" along both edges indicated as width dimension. Holes are located in such manner that the head of lag screws will fall between the raised diamonds, thereby allowing head of lag screw to bear upon the flat surface of the tread, permitting same to be drawn down to plank, thus insuring tight grip.

Expansion and Contraction: Sufficient space between ends of treads to be allowed to meet this condition; this space usually from ¼" to ½".

Lag Screws: Square head lag screws, ⅜" diameter, of sufficient length to reach to within ¼" of underside of planking; this length being dependent on whether bridge floor is of one or two course planking.

Application: Before applying treads, the inequalities occurring in the planking which may fall under the surface of the tread, should be smoothed off by adzing. The first tread at each end of bridge should be bent down into road bed at right angles at least 3", and if required, in addition, may be flared 1" in 4". If possible, treads should be fastened to the bridge structure itself at these points. It is advisable before applying treads to coat underside of each tread with tarvia, and the planks covered by the treads should be painted with two coats of creosote oil or carbolineum.

Southern Approach to Steel Bridge Over Fraser River, New Westminster, B. C.

EGYPTIAN IRON WORKS

Murphysboro, Illinois

Road, Street and Municipal Castings

Products: Grey Iron, Semi-Steel, Bronze and Brass Castings; Sewerage and Drainage Castings; Coal Hole Rings and Covers, Bridge Rockers and Bearing Plates; Name Plates and Bronze Tablets, Frogs.

Also Mining and Miscellaneous Contractors' Material and Supplies.

Scope of Business: The illustrations on this page present only in a general way the complete line of road, street and municipal castings this Company is prepared to supply. Our stock of patterns is sufficiently large to meet a wide variety of special requirements; and when necessary, new patterns can be promptly made at moderate cost.

All our products are guaranteed to be free from manufacturing defects. If not found entirely satisfactory, they may be returned—providing the customer has first written for and obtained our consent.

Service: Catalog sent on request. Quotations promptly submitted. Our delivery is equal to the best; where the conditions warrant, we carry standard materials in stock for immediate shipment.

Rocker and Plates

For Concrete Bridges: Cast Iron Rockers; Cast Iron Bearing Plates; Steel Bearing Plates; Structural Steel Expansion Devices; Bronze Bearing Plates; Copper Bearing Plates; Cast Iron Floor Drains; Cast Iron Name Plates; Bronze Name Plates; Cast Iron Forms over which to mold Bridge Railings.

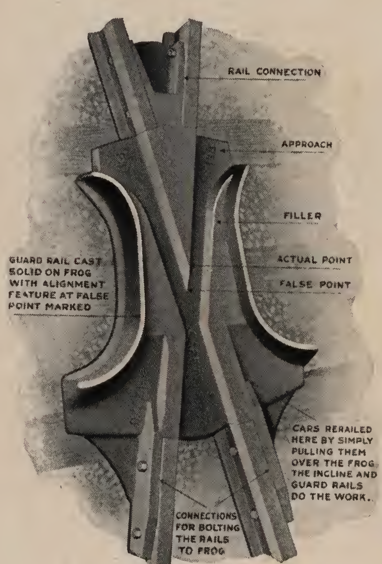
For Lighting System: Cast Steel Flange Plates; Cast Iron Pull Boxes with bronze covers; Cast Iron Entrance Boxes.

For Steel Bridges: Cast Iron Rockers; Cast Iron Shoes; Cast Steel Rockers; Cast Steel Shoes.

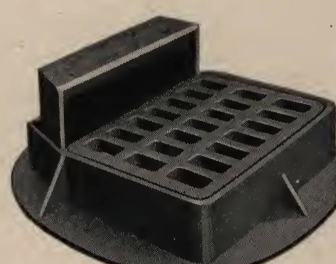
Municipal Castings: Manhole Covers, Curb and Gutter Inlets, Catchbasins, Coal Hole Rings and Covers, Lamp Hole Covers, Grates and Drains.

Reid Solid One-Piece Safety Frog: No bolts, rivets or plates to become loose. Guard rail cast integral with frog. The Reid Frog eliminates complicated construction, prevents wear and tear on rolling stock and improves safety conditions. An ideal frog for Industrial track.

General Jobbing: In addition to the above we operate a repair machine shop and jobging foundry, carry in stock pipe and fittings, boiler tubes, bolts and nuts, screws and rivets, babitt metals, etc.



Reid Safety Frog



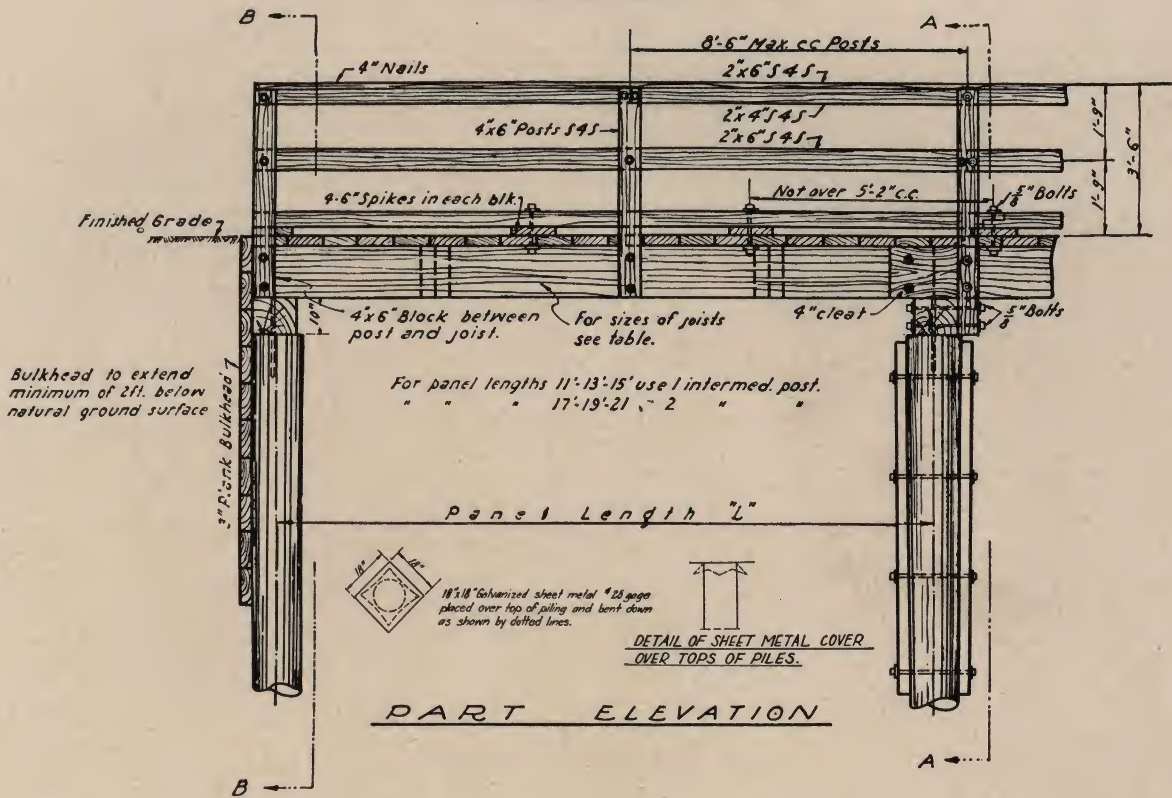
Curb Inlet—Style 2

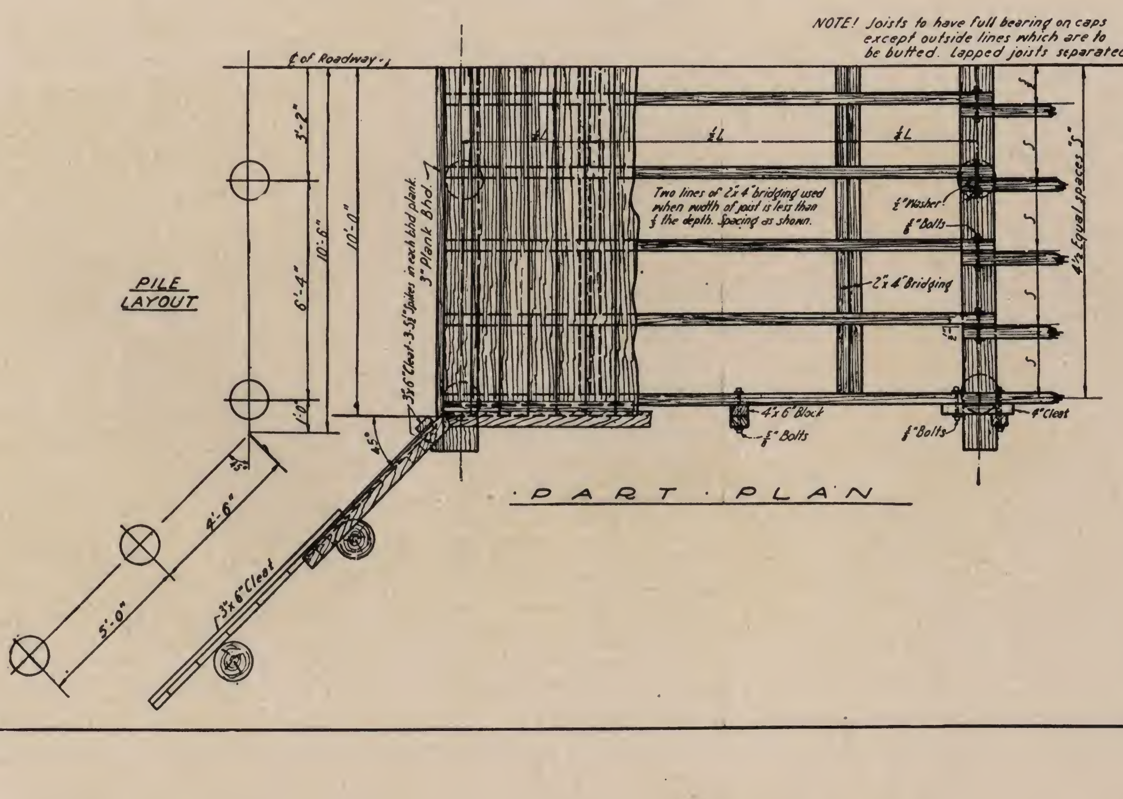
Manhole Cover

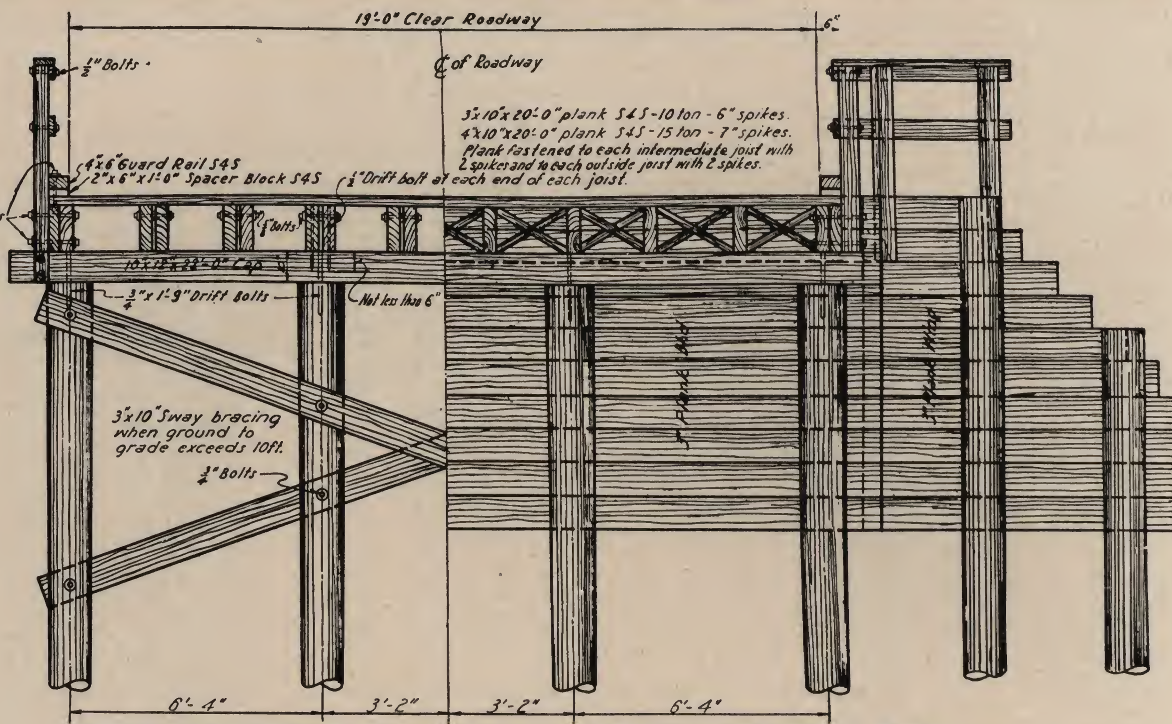
Bronze Name Plate

Creosoted Timber Trestle

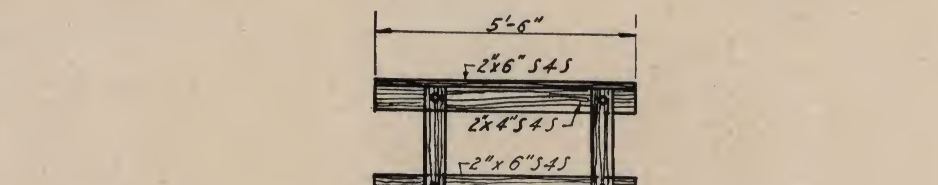
Standard Louisiana Highway Commission







HALF · SECTION · A-A · HALF · SECTION · B-B ·



DETAIL · OF · WING ·

View Normal to Face

Creosoted Timber Highway Bridges

Standard Specifications of U. S. Bureau of Public Roads

SPECIFICATION FOR TIMBER STRUCTURES CONSTRUCTION

1. **Description.** Timber structures shall be built where shown on the plans or directed by the Engineer and shall be constructed in accordance with the plans and specifications. This item shall include only such timber as is a part of the completed work. All timber for erection purposes, as falsework, forms, bracing, sheeting, etc., shall be furnished by the contractor at his own expense.

2. **Quality.** All timber shall be sound and sawed standard size, straight, and out of wind and shall be free from defects such as decay, worm holes, injurious shakes, checks and crooked, cross or spiral grain, large loose or unsound knots, knots in groups, large pitch pockets, or other defects that might impair its strength and durability. Wane may show on only one corner of a piece. Wane shall not exceed one-half the length of the piece nor measure more than 1 inch across the face of the wane. Not more than 10% of the pieces of one size may show any wane.

3. **Size.** Rough timbers when sawed to standard size, shall mean that they shall not be over ¼ inch scant from actual size specified. For instance, a 12 by 12-inch timber shall measure not less than 11¾ by 11¾ inch.

Dressed. Standard dressing means that not more than ¼ inch shall be allowed for dressing each surface. For instance, a 12 by 12-inch timber shall after dressing four sides, not measure less than 11½ by 11½ inch.

Permissible Stresses of Structural Timber (Revised, April, 1923)

When used with this specification the following stresses, in pounds per square inch, are permissible for structural timbers.

NAME	Axial Tension and Bending Stress	Horizontal Shear in Bending	Compression Parallel to the Grain			Compression Perpendicular to Grain	Shear Parallel to Grain
			End Bearing	L/D 0 to 10	L/D 10 to 30		
1	2	3	4	5	6	7	8
a Locust, black	2,200	220	1,800	1,600	$1800-25\frac{L}{D}$	600	350
c Maple, sugar or hard c Oak, Spanish (lowland) b Oak, tanbark b Oak, white	1,600	150	1,200	1,000	$1200-25\frac{L}{D}$	350	220
b Pine, Cuban b Pine, longleaf	1,600	120	1,200	1,000	$1200-25\frac{L}{D}$	250	180
b Fir, Douglas (Coast Region) c Pine, shortleaf	1,600	100	1,200	1,000	$1200-25\frac{L}{D}$	250	150
b Larch, western b Oak, Pacific post b Oak, burr c Pine, loblolly c Pine, table mountain c Tamarack	1,400	100	1,100	900	$1100-25\frac{L}{D}$	240	150
a Cypress, bald b Fir, Douglas (Mountain Region) c Hemlock, western c Hemlock, eastern c Pine, Norway c Pine, pitch a Redwood	1,200	90	1,000	800	$1000-25\frac{L}{D}$	180	130
a Cedar, western red a Chestnut c Pine, western yellow c Spruce, red c Spruce, sitka	1,000	60	800	700	$900-25\frac{L}{D}$	160	120
a Cedar, white c Pine, Lodgepole c Spruce, Englemann c Spruce, white	800	70	700	600	$800-25\frac{L}{D}$	140	100

L equals length of column, and D equals least side or diameter, both dimensions in the same unit either feet or inches. The unsupported length of wooden columns and compression members shall not exceed 30 times the diameter of least side.

a Very durable. b Durable. c Perishable.

4. **Dense Timber.** Dense timber shall be used for truss members, floor beams, stringers, caps and flooring.

a. Dense timber of longleaf pine, shortleaf pine and Cuban pine shall show at one end or the other an average of at least six annual rings per inch and at least one-third summer wood, all measured over the third, fourth and fifth inches on a radial line from the pith. Wide ringed material excluded by this rule shall be acceptable provided the amount of summer wood as above measured shall be at least one-half. Summer wood is the hard, dense and darker colored portion of the annual ring.

(1) In cases where timbers do not contain pith, and it is impossible to locate it with any degree of accuracy, same inspection shall be made over 3 inches in an approximate radial line beginning at the edge nearest the pith in timbers over 3 inches in thickness and in the second inch of the piece nearest to the pith in timbers 3 inches or less in thickness.

(2) In dimension material containing the pith but not a 5-inch radial line, which is less than 2x8, which is in section, or less than 8 inches in width, that does not show over 16 square inches on the cross section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5-inch radial line the inspection shall apply to the 3 inches farthest from the pith.

b. Dense timber of Coast Region Douglas fir shall be strong timber of medium rate of growth and show on one end or the other an average of at least six annual rings per inch and at least one-third summer wood measured over 3 inches on a line located as hereinafter described. Wide ringed material, excluded by this rule, shall be acceptable provided the amount of summer wood as above measured shall be at least one-half. Material in which the proportions of summer wood is not clearly discernible shall not be used.

(1) Any timber whose least dimension is less than 5 inches shall not show the pith on the inspection end; pieces whose least dimension is 5 inches or more may contain the pith.

(2) When the least dimension is 5 inches or more, the pith being present, the line over which the rate of growth and percentage of summer wood measurements shall be made, shall run from the pith to the corner farthest from the pith. The 3-in. line shall begin at a distance from the pith equal to 2 inches less than one-half the least dimension of the piece.

(3) For all pieces not having the pith present the center of the 3-inch line shall be at the center of the end of the piece and the direction of the 3-inch line shall be at right angles to the annual rings.

(4) If a radial line of 3 inches cannot be obtained, the measurement shall be made over the entire radial line that is available.

c. **Timber of Other Species.** Other species of timber for truss members, floor beams, caps and flooring shall be strictly first quality.

5. **Sound Timber.** Timber for columns, sills, wheel-guards, bulkhead sheeting, bracing and timber for other purposes, unless otherwise specified, shall fulfill the foregoing requirements except the density rules given in paragraph No. 4.

6. **Heart Requirement.** All untreated timber shall show at least eighty-five (85) per cent heart wood on any girth.

7. **Untreated Timber.** For designs based on a fiber stress in bending of 1,500 to 1,600 pounds per square inch, one of the following species of timber shall be used.

Douglas fir from Pacific Coast Region
Longleaf pine
Cuban pine
White oak
Spanish oak from lowland
Tanbark oak

8. **Treated Timber.** For designs based on a fiber stress in bending of 1,500 to 1,600 lbs. per square inch one of the following species of timber shall be used:

Douglas fir from Pacific Coast Region
Longleaf pine
Cuban pine
Shortleaf pine
White oak
Spanish oak from lowland
Tanbark oak

Timber treated by a pressure method to retain 8 to 12 lbs. of oil per cubic foot and so treated that all sapwood is entirely impregnated with creosote oil shall fulfill the requirements for untreated timber except that there shall be no heartwood requirement.

CONSTRUCTION

9. **Handling Treated Timber.** Treated timber shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the surface with tools. It shall be handled with rope slings. Cant dogs, hooks or pike-poles shall not be used.

10. **Cuts in Treated Timber.** All places where the surface of treated timber is broken by cutting, boring or otherwise, shall be thoroughly coated with hot creosote oil and then with a coating of hot tar pitch.

11. **Pile Caps.** Pile caps shall be level and have full even bearing on all piles in the bent and be secured to each pile by a ¾-inch diameter drift bolt extending at least 9 inches into the pile.

12. **Framing.** Truss and bent timbers shall be accurately cut, and framed to a close fit in such manner that they will have even bearing over the entire contact surface of the joint. No blocking or shimming of any kind will be allowed in making joints, nor will open joints be accepted. Mortises shall be true to size for their full depth and tenons shall make snug fit therein.

13. **Bolt Holes.** All bolt holes shall be bored with an augur 1/16 inch smaller in diameter than the bolt. Mortises and tenons shall be "draw-bored."

14. **Stringers.** Stringers shall be sized at bearings. Outside stringers may have butt joints but interior stringers shall be framed to bear over the full width of floor beam or cap at each end. The ends shall be separated at least ½ inch for the circulation of air and shall be securely fastened to the timber on which they rest.

15. **Floor Plank.** Roadway floor plank shall have a nominal thickness either of 4 or 3 inches as specified, and an actual width

of not less than 9½ inches. Sidewalk floor plank shall be surfaced to uniform thickness. It shall have an actual minimum width of 5½ inches and thickness of 1⅝ inches.

16. **Laying Floor Plank.** Floor plank shall be laid heart side down with ¼-inch openings and be spiked to each stringer or nailing strip with at least two 7-inch spikes for 4-inch plank and two 6-inch spikes for 3-inch plank. Rough plank shall be carefully graded as to thickness before laying, and be laid so that no two adjacent planks vary in thickness more than 1/16 inch. All floors shall be cut to a straight line along the sides of the roadway and walkway.

17. **Wheel-Guards.** Wheel-guards, as shown on the plans, shall be constructed on each side of the road. They shall be raised from the floor by blocks 3 inches thick by 1 foot long, spaced about 5 feet apart center to center, and be fastened in place by a ⅝-inch bolt passing through the wheel guard, each block and the floor plank.

18. **Railing.** Railings shall be built in accordance with the designs shown on the plans, and shall be constructed in a workmanlike and substantial manner. Unless otherwise noted all railing material shall be dressed on four sides (S4S).

19. **Bolts.** Bolts shall be of sizes specified and must be perfect in every respect. They shall have square heads and nuts and screw threads shall make close fits in the nuts. All bolts shall be effectually checked after the nuts are adjusted.

20. **Washers.** Washers shall be used between all bolt heads and nuts, and wood. Cast washers shall have a thickness equal to the diameter of the bolt and a diameter of four times the thickness. For plate washers the size of the square shall be equal to four times, and the thickness equal to one-half the diameter of the bolt.

PRESERVATIVE TREATMENT

21. **Description.** Whenever specified timber shall be treated for preservation and prior to treatment timber shall be cut and framed. After treatment no unnecessary cutting of treated piles or timber will be allowed. (The requirements for treatment of timber for use in sea-water are included with the Specification for Piling, revised May 14, 1924.)

21a. The range of pressure, temperature and time duration shall be controlled so as to result in maximum penetration by the quantity of preservative injected, which shall permeate all of the sapwood, and as much of the heartwood as practicable.

Preservative Specification

	Creosote Oil			Creosote Coal Tar Solution
	Grade 1	Grade 2	Grade 3	
1—It shall not contain water in excess of	3%	3%	3%	3%
2—It shall not contain matter insoluble in benzol in excess of	0.5%	0.5%	0.5%	2.0%
3—Specific gravity of oil at 38°/15.5°C, shall not be less than	1.03	1.03	1.03	1.05—1.12
4—The distillate based on water-free oil shall be within the following limits:				
Up to 210°C, not more than	5%	8%	10%	5%
Up to 235°C, not more than	25%	35%	40%	25%
5—The float test of residue above 355°C shall not exceed 50 sec. at 70°C, if the distillation residue above 355°C exceeds	5%	5%	5%	26%
6—Coke residue of oil not more than	2%	2%	2%	6%
7—The foregoing tests shall be made in accordance with standard methods of A. S. T. M. Designation D38-18.				

The amount of preservative and manner of treatment shall as indicated on the plans and shall fulfill the following requirements:

21b. Timber shall be treated with the preservative specified by any standard full cell process to retain not less than 12 lbs. of the preservative per cubic foot or by any standard empty cell process to retain not less than 8 lbs. of the preservative per cubic foot, except Douglas fir which shall be treated to retain not less than 10 lbs. by any standard full cell process or 6 lbs. by any standard empty cell process.

23. **Material.** The preservative shall be one of the following grades of creosote oil or creosote-coal-tar solution as directed by the Engineer, or indicated on the plans and shall meet the following requirements:

PAINTING

24. **Treated Timbers.** Hot creosote oil shall be poured into the bolt holes before the insertion of the bolts, in such a manner that the entire surface of the holes shall receive a coating of oil. After the necessary cutting has been done to receive the cap, the heads of piles shall be given three coats of hot creosote oil. They shall then be covered with a coat of hot tar pitch over which shall be placed a sheet of 3-ply roofing felt or galvanized iron, or a covering may be built up of alternate layers of hot tar pitch and loose-woven fabric similar to membrance waterproofing using four layers of pitch and three of the fabric. The cover shall measure at least 6 inches more in each dimension than the diameter of the pile and shall be bent down over the pile and the edges fastened with large headed nails, or secured by binding with galvanized wire. After the cover is in place the cap shall be placed as described in Article No. 11.

25. **Untreated Timbers.** In structures of untreated timber the following surfaces shall be thoroughly coated with a thick coat of red lead paint, hot tar, hot asphaltum, or hot or cold tar creosote before assembling. Heads of piles, ends, tops, and all contact surfaces of pile caps, floor beams, and stringer ends, joints and all contact surfaces of truss members, laterals and braces.

The back face of bulkheads and all other timber in contact with earth shall be thoroughly coated with one of the materials specified above or a carbolineum.

26. **Railings.** Unless otherwise specified railings shall be made of untreated dressed lumber and shall be painted with two coats of paint composed of 85% pure white lead and 15% zinc white mixed in pure raw linseed oil.

27. **Bolts.** All bolts passing through non-resinous wood shall be painted with two coats of red lead paint at least 85% pure.

28. **Basis of Payment.** This work will be paid for at the contract unit price per thousand feet board measure for untreated timber or treated timber, as the case may be, complete in place according to the plans or as directed by the Engineer, which price will include all materials, excavation, equipment, tools, labor, painting, preservative treatment and all work incidental thereto. No additional allowance will be made for spikes, nails, bolts, washers, drift bolts, etc.

In computing the quantity of timber, nominal sizes will be used.

SPECIFICATION FOR TREATMENT OF PILING

Treatment of Piles. When noted on the plans, piles shall be treated with the creosote oil or creosote-coal-tar solution described in the Specification for Timber Structures, revised May 14, 1924. (See above).

The ranges of pressure, temperature and time duration of treatment shall be controlled so as to result in maximum penetration of the quantity of preservative injected, which shall permeate all of the sapwood, and as much of the heartwood as practicable.

For general construction, not in sea-water, piles shall be treated to retain not less than 12 lbs. of the preservative per cubic foot of wood by any full cell process or not less than 8 lbs. by any standard empty cell process.

Piles for use in water liable to be infested by marine borers along the North Atlantic coast shall be treated to retain not less than 20 lbs. of Grade 1 creosote oil by any standard full cell process, and along the Pacific coast not less than 16 lbs. of Grade 1 creosote oil by any standard full cell process for all kinds of timber except Douglas fir. Douglas fir shall be treated to retain not less than 12 lbs. of Grade 1 creosote oil by any standard full cell process. Timber for other uses in these waters shall be treated by a full cell process so as to have full penetration of all sapwood and as much of the heartwood as practicable and to retain not less than 12 lbs. of Grade 1 creosote oil, except Douglas fir which shall be treated to retain not less than 10 lbs. by any standard full cell process.

Piles for use in water liable to be infested by marine borers along the South Atlantic and Gulf coasts shall be treated to retain not less than 24 lbs. of Grade 1 creosote oil by any standard full cell process. Timber for other uses in these waters shall be treated by any standard full cell process so as to have full penetration of all sapwood and as much of the heartwood as practicable and to retain not less than 16 lbs. of Grade 1 creosote oil.

Treated piles and timbers shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the surface with tools. They shall be handled with rope slings. Cant dogs, hooks, or pike-poles shall not be used.

All places where the surface of treated piles or timbers is broken by cutting, boring or otherwise, shall be thoroughly coated with hot creosote oil and then with a coating of hot tar pitch. Hot creosote oil shall be poured into the bolt holes before the insertion of the bolts in such manner that the entire surface of the holes shall receive a coating of the oil.

After the necessary cutting has been done to receive the cap, the heads of treated piles shall be given three coats of hot creosote oil. They shall then be covered with a coat of hot tar pitch over which shall be placed a sheet of three ply roofing felt or galvanized iron, or a covering may be built up of alternate layers of hot tar pitch and loose woven fabric similar to membrane waterproofing, using four layers of pitch and three of the fabric. The cover shall measure at least 6 ins. more in each dimension than the diameter of the pile and shall be bent down over the pile and the edges fastened with large-headed nails or secured by binding with galvanized wire.

Highway Guard Rail

Cable Guide Railing

Specifications New York State Highway Department

Work. Under this item the contractor shall furnish and erect guide railing as shown on the standard structure sheet at such places as indicated on the plan or as otherwise directed by the engineer.

Stretches of guide railing more than 500 feet in length shall have two intermediate anchors for each 500 foot stretch or fraction thereof.

Material. The posts shall be made of concrete consisting of one part of Portland cement, two parts of concrete sand and three parts of crushed stone or screened gravel, all measured in loose bulk in boxes or forms of known capacity.

All posts shall be reinforced as shown on the standard structure sheet with fabricated steel bars meeting all the requirements of the Standard Specifications of the A. S. T. M. Serial Designation A-15-14, or, at the contractor's option, with steel fabric meeting all the requirements of the Standard Specifications of the A. S. T. M. Serial Designation A-82-21T.

The contractor shall so manipulate and cut the cable as to produce a minimum number of splices.

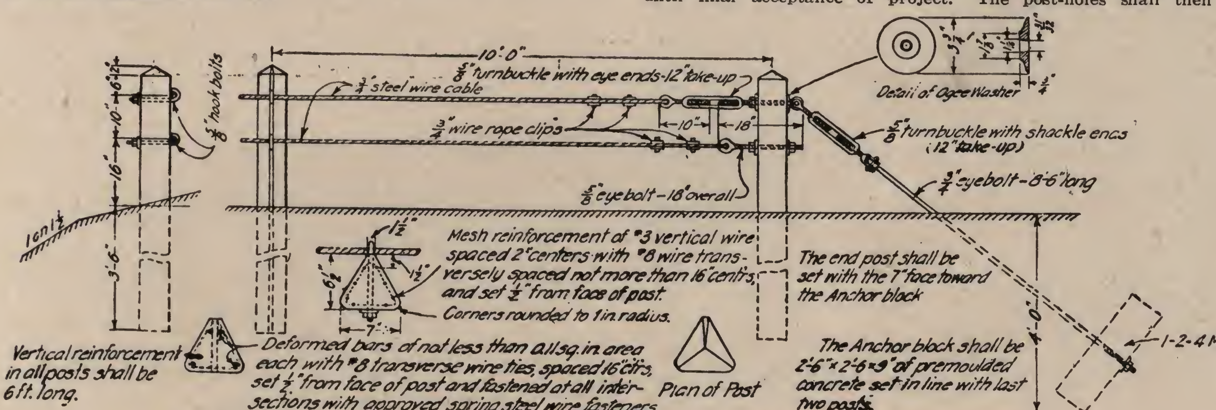
The threaded portions of all fittings and fastenings shall have a continuous coating of pure zinc of a uniform thickness, so applied that it will adhere firmly to the surface of the thread, and it shall be capable of withstanding two immersions, of one minute each, in a standard testing solution of copper sulphate without showing any trace of metallic copper on the steel.

These threaded portions shall receive, after erection, two coats of aluminum paint meeting the requirements under MATERIALS OF CONSTRUCTION.

Measurement and Payment. The quality of guide railing to be paid for under this item shall be the number of linear feet outside to outside of posts, completed in place, as shown on the plans, or as directed by the engineer.

The price bid shall cover the furnishing and placing of all material, the excavation, backfilling and all other labor and incidental expenses necessary to satisfactorily complete the work.

The rails shall have the dimensions shown on the plans, and shall be of yellow pine, white oak, post oak or cypress. They shall be of until final acceptance of project. The post-holes shall then be



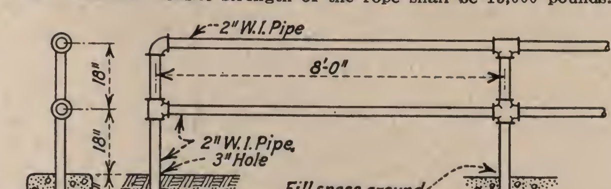
Cable Guide Railing With Concrete Posts, Standard New York State Highway Department.

All exposed surfaces shall be finished true to line. No plastering of any surface will be permitted.

After erection all exposed surfaces of the post shall receive a uniform application of a solution consisting of 8 pounds of zinc sulphate to 1 gallon of water. This application shall be permitted to set for at least 48 hours, after which the posts, when perfectly dry, shall receive two coats of white guide rail paint meeting the requirements under MATERIALS OF CONSTRUCTION.

Cable shall be three strand, seven wire to the strand, double galvanized steel wire cable of three-quarter-inch diameter. Individual wires shall be not less than .120 inch diameter.

The lay of the finished rope shall not be more than 7½ inches. The lay of the wires in the strand shall not be more than 4½ inches. The minimum tensile strength of the rope shall be 15,000 pounds.



Pipe Railing, Standard, New York State Highway Department.

Each wire of the cable and all fittings and fastenings, except threaded portions, shall be galvanized by the "Hot Dip Method" and shall have a continuous coating of pure zinc of a uniform thickness, so applied that it will adhere firmly to the surface of the wire, and it shall be capable of withstanding four immersions in a standard testing solution of copper sulphate without showing any trace of metallic copper on the steel. The first three immersions shall be for a period of one minute each and the fourth immersion for a period of one-half minute.

All wire rope must be shipped upon substantial wooden reels. Each reel shall have the length and weight of the rope plainly and indelibly marked on a strong tag, firmly attached.

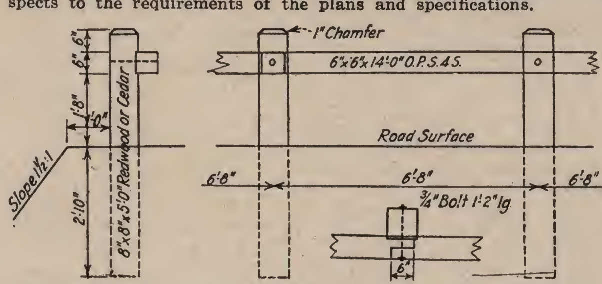
The wooden reel shall be mounted so that it will revolve and the rope run off by pulling straight ahead.

back-filled, using great care to see that only suitable material is as set forth under Second Field Coat for metal structures.

Wood Guard Rail

Specifications North Carolina State Highway Department.

1. Wooden guard rails shall be constructed where called for on the plans or as directed by the engineer, and shall conform in all respects to the requirements of the plans and specifications.



Low Wood Guard Rail, Standard, California State Highway Department.

2. **Materials.**—The posts shall be of sound heart red cedar, yellow locust, white oak, post oak, chestnut, long-leaf yellow pine, juniper or red heart cypress, and of the dimensions shown. If round posts are used, they shall be peeled and trimmed of all knots and knobs, and shall be straight and smooth. These posts shall be at no place less than six (6) inches in diameter, or six (6) inches square, but both round and square posts shall not be used on one project.

The rails shall have the dimensions shown on the plans, and shall be of yellow pine, white oak, post oak or cypress. They shall be of first-class timber, free from all defects that would impair their strength, and shall be dressed on all sides.

3. **Construction Methods.**—The posts shall first be thoroughly coated with bitumen or creosoted for a distance of four and one-half (4½) feet at their butt ends. They shall then be set vertically, to

the full depth shown on the plans, and accurately lined and relined until final acceptance of project. The post-holes shall then be back-filled, using great care to see that only suitable material is used in the backfill, and that it is thoroughly tamped. The tops of the posts shall be sloped on top and sawed to exact grade after the tamping of the backfill is finished. The railings shall be securely spiked in place.

4. **Paint.** The guard planks, posts and all joints when dry, shall be given three (3) coats of paint complying with paint requirements as set forth under Second Field Coat for metal structures.

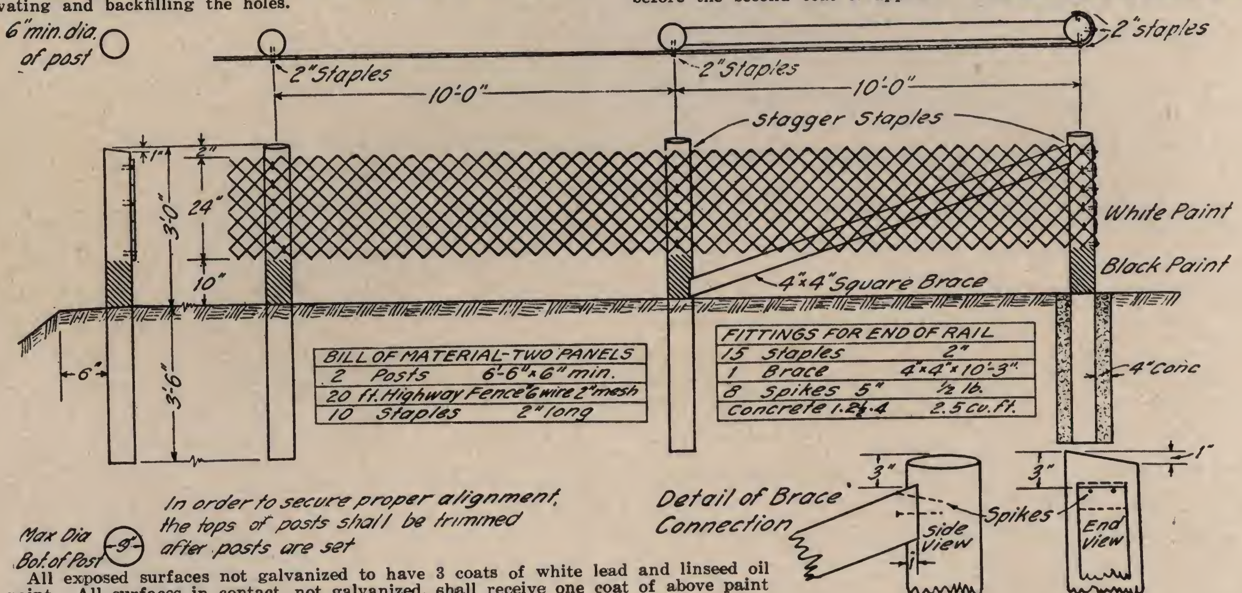
5. **Testing Sample of Paint.** Before ordering the paint, a sample shall be furnished the engineer, which sample, if approved, will be used in determining the merits of the paint furnished on the work. All paints used must equal the sample in quality. Samples of the paint delivered at the shop and in the field shall be furnished the engineer by the contractor. These samples shall be tested at such laboratory as the engineer may direct before any paint is applied. If found advisable or expedient to inspect and make the necessary laboratory tests at the place of manufacture, all facilities shall be given for the performance of this work at the expense of the manufacturer.

6. **Basis of Payment.** Guard rail will be paid for at the contract price per linear foot, which shall be payment in full for all materials and labor, including timber, bitumen, paint, labor of excavating and backfilling the holes.

than three (3) inches. No style of fabric will be approved for use under these specifications without submission of a sample for inspection. Fabric shall be of such a character that it may be installed easily and after being stretched and secured, it shall not show undue sag under its own weight.

Method of Construction.—Posts shall be set plumb and true to the lines shown on the plans. The back filling shall be tamped thoroughly. End posts shall be set in concrete and braced to the next adjacent post as shown on the plans. The woven wire shall be stretched on the side of the posts next the highways and secured as shown on the plans. The bottom of the wire shall be eighteen (18) inches above the ground. Stretchers of an approved type shall be used, and the fabric stretched to the satisfaction of the engineer. Intermediate bracing panels spaced not over three hundred (300) feet shall be constructed as shown on the plans. These panels shall be used for stretching from.

Painting.—After the entire guard rail is in place and satisfacfactory to the engineer, the posts and wooden diagonal bracing shall be given two coats of white lead and oil, and the woven wire and wire bracing one field coat of white lead and oil. All paint shall contain twenty (20) pounds of white lead to one (1) gallon of oil. All paint shall be applied on a thoroughly dry surface and time shall be allowed for the first coat to thoroughly dry before the second coat is applied. All framed bracing timber or



All exposed surfaces not galvanized to have 3 coats of white lead and linseed oil paint. All surfaces in contact, not galvanized, shall receive one coat of above paint before construction.

Posts shall be straight sound chestnut, white oak, yellow locust, white or red cedar, 6" min. diam. and creosoted by dipping the lower 4'-4".

All iron and steel to be galvanized, the galvanizing being done after weaving.

Type "E" Guard Rail, Division of Highways, Ohio

Woven Wire Guard Rail

Specifications New Mexico State Highway Department

Description.—Woven wire guard rail shall be erected at such places along the roadway as may be deemed necessary.

Wooden Posts.—The wooden posts shall be of well seasoned straight sound cedar or spruce. Round or square posts may be used. If round, the diameter shall be not less than six (6) inches; if square, the sides shall not be less than six (6) inches. The bottom of the posts shall be sawed off square. The bark shall be removed and all knots hewn down to the face, and the surface shaved smooth. After the post is set and the wire in place, the top shall be sawed off to the bevel as shown on the plans.

Treatment of Posts.—The lower portion of all posts shall be treated with creosote paint before being set. The creosote shall be applied by means of a brush in a full free coating, covering the bottom and extending up the sides to a point at least twelve (12) inches above the ground line. No posts shall be treated unless thoroughly dry. End posts which are set in concrete shall not be treated.

Woven Wire.—Woven wire of an approved type shall be used. The individual wires shall be No. 9 and thoroughly galvanized before fabrication. All wires shall be diagonal unless vertical stay wires are used. No horizontal wires will be allowed. After fabrication, the fabric shall be given one coat of white lead and oil which shall contain twenty (20) pounds of white lead to one (1) gallon of oil. The width of the fabric shall be twenty-four (24) inches. The greatest dimension of any mesh shall not be more

posts that are notched shall have the framed or notched portions thoroughly coated with white lead before connecting up.

Pipe Railing

Specifications New Jersey State Highway Department

Description.—Pipe Railing shall consist of galvanized iron or steel pipe and malleable fittings erected at such points as may be indicated, or directed in accordance with these specifications.

Galvanized Pipe Rails.—All pipe shall be made from the best grade of galvanized wrought iron pipe that is equal in every respect to the best grade of "Byers' Wrought Iron Galvanized Pipe." All such pipe must have an even, smooth surface, be full weight and thickness, well threaded and free from rust or cracks. All fittings used in pipe guard railing shall be galvanized and made from malleable iron that is free from flaws, cracks, etc. They shall be neatly threaded or bored to the required size needed for the proper installation of the pipe.

Construction Methods.—The pipe posts and anchor bolts shall be set in concrete or masonry and shall be grouted in place securely with a grout composed of one (1) part of Portland cement and two (2) parts of approved, clean sand. The posts shall be screwed into the fittings and the rails shall screw into the end fittings and slide through intermediate fittings. All threaded joints shall be coated with white lead before assembling. The railing shall be erected satisfactorily and shall be straight and true after erection. All spots where the galvanizing has been damaged by tools in erecting and exposed threads shall be painted with aluminum paint.

MACWHYTE COMPANY

Home Office and Works, 2933 Fourteenth Avenue, Kenosha, Wisconsin

Manufacturers of Wire, Wire Rope, Wire Products

BRANCH OFFICES

New York | Pittsburgh | Chicago | Tulsa | Portland

Products: WIRE ROPE FOR CONCRETE MIXERS, STEAM SHOVELS, CRANES, DERRICKS, DRAG BUCKETS, EXCAVATORS, CABLEWAYS, HOISTS AND OTHER ENGINEERING EQUIPMENT. ALSO GALVANIZED WIRE ROPE FOR HIGHWAY GUARD RAIL, WIRE ROPE CLIPS AND OTHER FITTINGS.

Galvanized Wire Rope for Highway Guard Rail: Made of three strands of seven (7) wires, each, twisted together as shown in accompanying illustration. The wires are strong, tough, and are heavily galvanized to

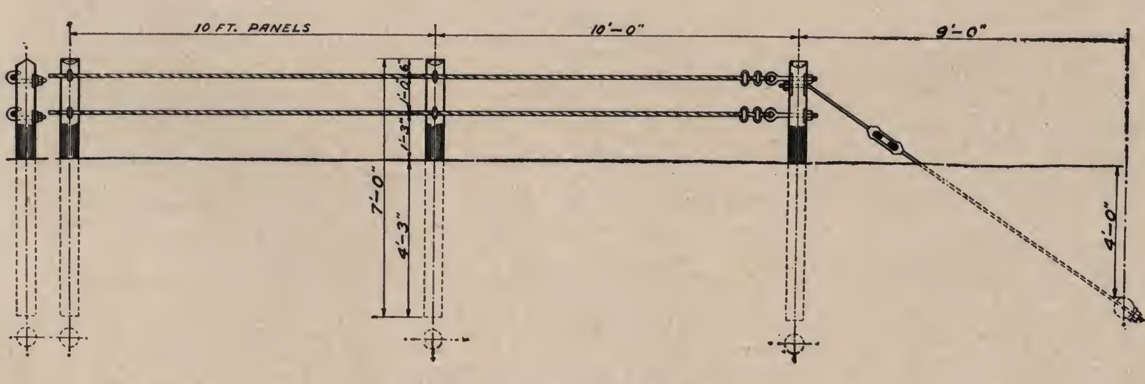
protect from corrosion. Made in strict accordance with the specifications of all State Highway Departments. Prompt shipment from mill in full reels or cut to length as required. Supplied usually in ¾ inch diameter, weighing about 89 pounds per 100 feet.

Hoisting Rope: Made of fine steel wire and very flexible, is used for hoisting purposes on concrete mixers, power shovels, locomotive cranes and other machines

Guarding a Dangerous Approach

used by contractors in road building. It contains 6 strands of 19 wires each, around a hemp center. Ask for a Macwhyte Plow Steel Hoisting Rope when in need of a line.

Fittings: We have the latest specifications from the highway departments of practically all the states, and will be glad to help you work out your guard rail problems. Full information is available from any Macwhyte sales office or agent.



A Typical Highway Guard Rail Installation

AMERICAN STEEL & WIRE COMPANY

American—Guard Rail Strand—Galvanized or Extra Galvanized

THREE STRANDS—SEVEN WIRES TO THE STRAND

SALES OFFICES

Chicago, 208 So. La Salle St.
Cleveland, Rockefeller Bldg.
Detroit, Foot of First St.
Cincinnati, Union Trust Bldg.
Minneapolis-St. Paul, Merchants National Bank Bldg.
St. Louis, 506 Olive St.
Kansas City, 417 Grand Ave.
Oklahoma City, First National Bank Bldg.
Birmingham, Brown-Marx Bldg.
Memphis, Union and Planters Bk. Bldg.

New York, 30 Church St.
Boston, Statler Bldg.
Pittsburgh, Frick Bldg.
Philadelphia, Widener Bldg.
Atlanta, 101 Marietta St.
Worcester, 94 Grove St.
Baltimore, 32 So. Charles St.
Buffalo, 670 Ellicott St.
Wilkes-Barre, Miners Bank Bldg.

Dallas, Praetorian Bldg.
Denver, First National Bank Bldg.
Salt Lake City, Walker Bank Bldg.
United States Steel Products Company:
San Francisco—Russ Bldg.
Los Angeles—2087 E. Slavson Ave.
Portland—777 Nicolai St.
Seattle—4th Ave. So. and Connecticut St.

For Reinforcement Fabrics, see pages 94-95-96

Products: AMERICAN GUARD RAIL STRAND AND FITTINGS, BANNER RAILROAD RAIL AND IDEAL U STEEL POSTS FOR HIGHWAY SIGNS AND FENCES; AMERICAN WIRE ROPE FOR ROAD BUILDING EQUIPMENT; CONCRETE REINFORCEMENT FOR HIGHWAYS AND ROADWAYS.

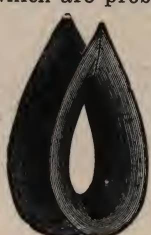
This Guard Rail Strand is usually made to conform to specifications as submitted by the State Highway Commissions of the various states, the most common of which are probably the Pennsylvania and Ohio State Specifications calling for Extra Galvanized, and the Missouri State covering galvanized Guard Rail Strand.

Size ¾ in. is generally used, although ⅝ in., ⅞ in. and 1 in. are sometimes called for.

In case of impact the strand will deflect toward the road.

American guard rail strand eliminates cost of upkeep.

Stocks maintained at many sales branches.



Galvanized Oval Thimble

American Guard Rail Strand

Tiger Rope Clip Galvanized, Light, Durable, Easily Applied. Drop Forged

American Guard Rail Strand With Reinforced Concrete Posts

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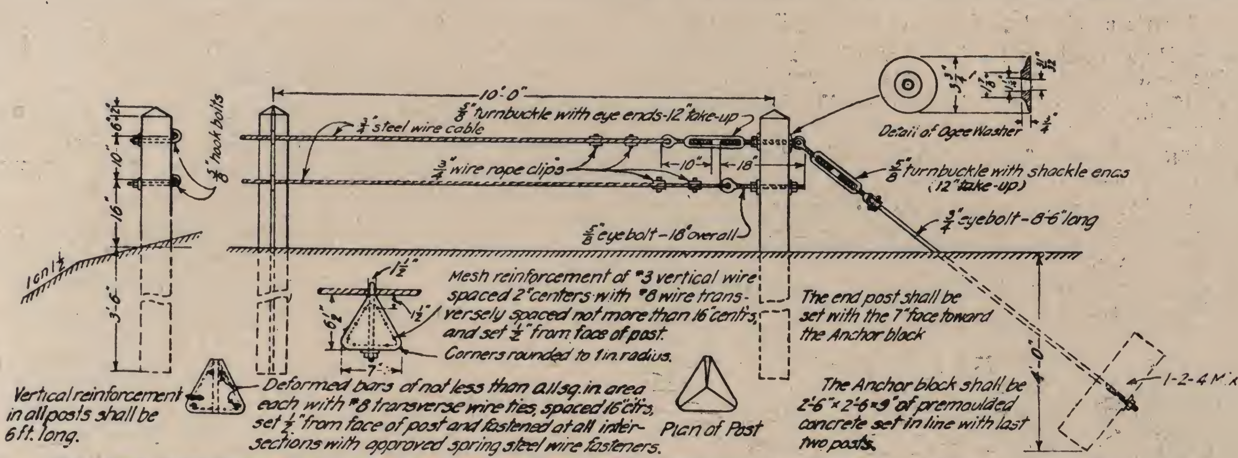


New York State Highway Department Standard Plan for Guard Rail Strand Mounted on Steel Mesh Reinforced Triangular Concrete Posts

Specification: New York State Highway Department Standard Plan for Guard Rail Strand Mounted on Steel Mesh Reinforced Triangular Posts:

Work: Under this item the contractor shall furnish and erect guide railing as shown on the standard sheet at such places as indicated on the plans or as otherwise directed by the Engineer.

Not more than five hundred linear feet of guide railing shall be constructed in any one continuous length. Stretches of railing more than 500 ft. in length shall have intermediate anchors.

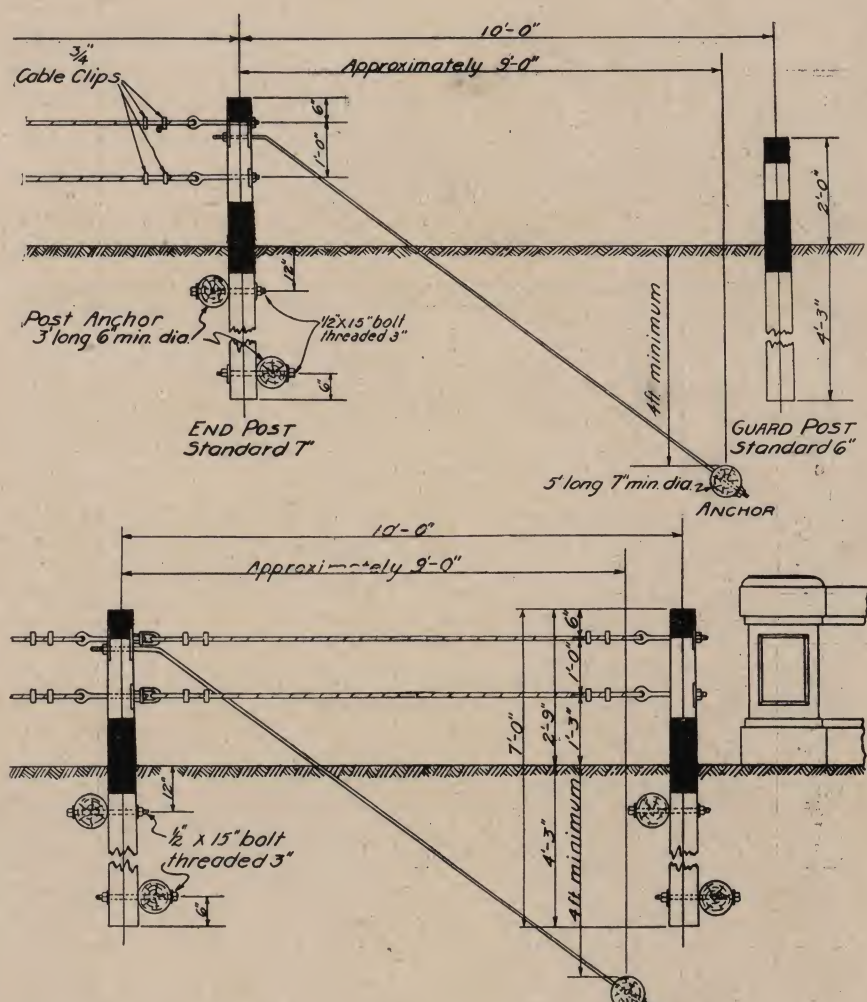
Material: The posts shall be made of concrete consisting of one part of Portland Cement two parts of concrete pavement sand and three parts of crushed stone or screened gravel, all measured in loose bulk in boxes or forms of known capacity.

All exposed surfaces shall be finished smooth and true to line. No plastering of any surface will be permitted.

Guard Rail shall be three strand, seven wires to the strand, extra galvanized steel wire cable of three quarters in. diameter. Individual wires to be not less than .120 in. diameter.

The Minimum tensile strength of the strand shall be 15,000 lbs.

American Guard Rail Strand is usually put up on wooden Reels containing 2,000 ft., 2,500 ft. and 5,000 ft. lengths, longer or shorter lengths can be furnished if required.



Michigan State Highway Department Standard Plan for Guard Rail Strand Mounted on Wooden Posts

Continued on Next Page

American Wire Rope for Road Building Equipment

Wire Rope used on road equipment must be of very high grade and in most cases possess high tensile strength. The following constructions and sizes are ordinarily used:

Lifting or Hoisting lines usually 6x19 Monitor Silver Strand, Hemp or Wire Core.

Boom Lines usually 6x19 Plow, Hemp or Wire Core.

Bucket Lines usually 6x29 Monitor Silver Strand, Hemp or Wire Core.

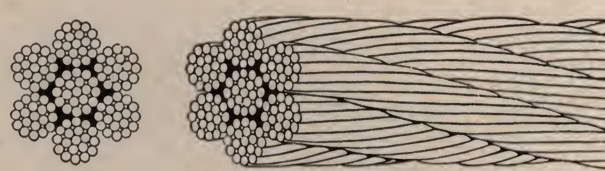
Drag Lines usually 6x21 Monitor Silver Strand, Hemp or Wire Core.

In cases where loads are very heavy and rope overwinds on drums, our Monitor Silver Strand with wire center will give excellent service.

If loads are lighter, and where ropes do not overwind on drums, our Monitor with hemp core is used. If no great strength is required our Plow Steel with hemp core is suggested.

These ropes are used for the following contractors' equipment: concrete mixers, cranes, buckets, road pavers, steam shovels, draglines, trench hoes, hoists, derricks, conveyors, cableways, excavators, scrapers, etc.

6x19 Hemp Center



6x19 Wire Center

MONITOR SILVER STRAND							PLOW STEEL ROPE					
1 List price per foot	2 Circumference in inches	3 Approx. Weight per foot in lbs.	4 Approx. St'gth in tons of 2000 lbs.	5 Proper working load in tons of 2000 lbs.	6 Diam. of drum or sheave in ft. advised	Diameter in inches	1 List price per foot	2 Circumference in inches	3 Approx. Weight per foot	4 Approx. St'gth in tons of 2000 lbs.	5 Proper working load in tons of 2000 lbs.	6 Diam. of drum or sheave in ft. advised
6 Strands, 19 Wires to Strand, 1 Hemp Core							6 Strands, 19 Wires to Strand, 1 Hemp Core					
.75	4	2.45	69	14	5	1¼	.65	4	2.45	58	12	5
.62	3½	2	56	11	4½	1⅛	.54	3½	2	47	9.5	4.5
.50	3	1.58	45	9	4	1	.43	3	1.58	38	7.6	4
.39	2¾	1.20	35	7	3½	⅞	.34	2¾	1.20	29	5.8	3.5
.31	2¼	.89	26.3	5.3	3	¾	.26	2¼	.89	23	4.6	3
.22½	2	.62	19	3.8	2½	⅝	.19	2	.62	15.5	3.1	2.5
.19	1¾	.50	14.5	2.9	2¼	9/16	.16	1¾	.50	12.3	2.4	2.25
.17	1½	.39	12.1	2.4	2	½	.14	1½	.39	10	2	2
.15½	1¼	.30	9.4	1.9	1¾	7/16	.13	1¼	.30	8	1.6	1.75
.14½	1⅛	.22	6.75	1.35	1½	⅜	.12½	1⅛	.22	5.75	1.15	1.50
.13½	1	.15	4.50	.9	1¼	5/16	.12¼	1	.15	3.8	.76	1.25
.13	¾	.10	3.15	.63	1	¼	.12	¾	.10	2.65	.53	1
6 Strands, 29 Wires to Strand, 1 Hemp Core							6 Strands, 29 Wires to Strand, 1 Hemp Core					
.805	4	2.45	58	11	4.37	1¼	.70	4	2.45	55	11	4.37
.685	3½	2	46	9.2	3.93	1⅛	.59	3½	2	44	9	3.93
.545	3	1.58	37	7.4	3.50	1	.47	3	1.58	35	7	3.50
.425	2¾	1.20	29	5.8	3.06	⅞	.37	2¾	1.20	27	5	3.06
.335	2¼	.89	23	4.6	2.62	¾	.285	2¼	.89	21	4	2.62
.25	2	.62	16	3.2	2.18	⅝	.215	2	.62	14	3	2.18
.21	1¾	.50	12.5	2.5	1.96	9/16	.18	1¾	.50	11.5	2.3	1.96
.185	1½	.39	9.75	1.9	1.75	½	.155	1½	.39	9.25	1.85	1.75
.17	1¼	.30	7.50	1.5	1.53	7/16	.145	1¼	.30	7.2	1.4	1.53
.16	1⅛	.22	5.30	1.06	1.31	⅜	.1375	1⅛	.22	5.1	1	1.31

MONITOR DRAG LINE ROPE

6 Strands, 21 Wires to Strand, 1 Hemp Core

.75	4	2.45	69	14	5	1¼
.62	3½	2	56	11	4½	1⅛
.50	3	1.58	45	9	4	1
.39	2¾	1.20	35	7	3½	⅞
.31	2¼	.89	26.3	5.3	3	¾
.22½	2	.62	19	3.8	2½	⅝

For wire center cables, add 10 per cent to list prices.

Other sizes, grades and constructions supplied; information furnished on request.

HUBBARD AND COMPANY

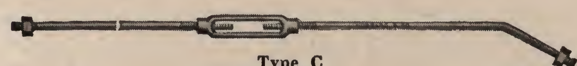
Factories: Pittsburgh, Oakland, Calif., Chicago

Manufacturers of Drop Forged Guard Rail Fittings, Pole Line Hardware and Peirce Construction Specialties

Products: Galvanized Drop Forged Turnbuckles, Turnbuckle Rods, Cable Retainer Bolts and Plates, Post and Bearing Plates, Steelwing Anchors, Rock Guy Bolts with Wedges, Eye Bolts, Post Clamps, Anchor Rods, Drop Forged Wire Rope Clips, Machine Bolts, Carriage Bolts, Round and Square Washers.

Also a complete line of long and "D" Handle Shovels, Clay Picks, Mattocks, Grub Hoes, etc., Pole Line Hardware and Peirce Construction Specialties.

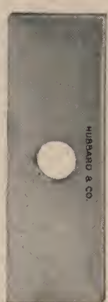
Hubbard Turnbuckle Rods: Hot Galvanized.



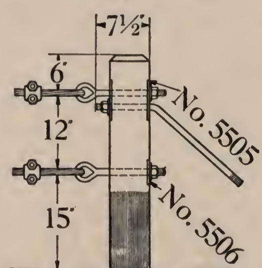
Type C
No. 5511

Hubbard Post and Bearing Plates: Hot Galvanized.

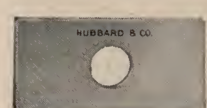
No. 5505



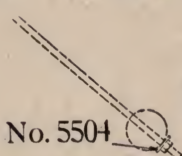
No. 5504



An Installation of Hubbard Post Plates Nos. 5505 and 5506.



No. 5506

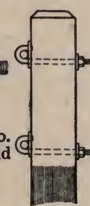


An Installation of Hubbard Bearing Plate No. 5504 on the end of No. 5511 Anchor Rod.

Hubbard Cable Retainer Bolt and Plate: Hot Galvanized.

No. 5510

No. 5508



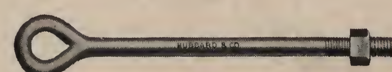
An installation of No. 5508 Retainer Bolt and No. 5510 Plate.

Hubbard Drop Forged Wire Rope Clips: Hot Galvanized.

No. 7486

Two No. 7486 Wire Rope Clips are used to dead-end this cable.

Hubbard Drop Forged Eye Bolts: Hot Galvanized.



No. 5525

Hexagon Nuts are furnished as illustrated.

Bulletin No. 4 gives a complete listing of all Hubbard Drop Forged Guard Rail fittings and their installations. Write for your copy today.

Line of Cable Guard Fence Using Hubbard Fittings Listed Above Along Edge of Highway on High Fill to Protect Motorists.

AMERICAN WIRE FENCE COMPANY

7 South Dearborn St., Chicago, Illinois

Manufacturers of American Life-Net Road Guard

FACTORY: LIBERTYVILLE, ILLINOIS

Products: American Life Net Road Guard. Also Chain Link Fence, Lawn Fence and Field Fence, Posts, Poultry Netting, Barbed Wire, Gates; and the American System of Reinforcing.

American Life Net Road Guard: installed at all danger points gives assurance of elasticity, permanency, safety.

Woven chain link steel fence, the newest development in highway protection to motorists, is today widely specified. State and County Highway Commissioners and engineers in practically every state in the union

have affirmed that woven chain link guard holds cars on the road without serious danger to car or occupants.

American Life Net Road Guard provides every factor of safety and permanence, and maximum economy in both installation and maintenance.

It is a highly elastic net of woven steel, a net that will yield immediately yet gradually. It acts as a gigantic buffer, elongating in proportion to the shock of collision and holding all cars on the road.

Specifications of American Life Net Road Guard: Made of No. 6 W. & M. gauge copper having steel wire in two inch mesh, heavily galvanized after woven. Shipped in 100 foot rolls for convenience in handling.

Advantages: State and County Highway Commissioners of every State of the union are installing this new and far safer road guard. We anticipate that only a few years will record the complete passing of all wooden highway guards.

1. **Economically Installed:** A 5-ton truck carries a mile of American Life Net Fence. No notching or drilling of posts. Simply fasten with 2-in. staples. The result is a lasting and positive guard against accident.

2. **Quickly Seen at Night:** American Life Net serves

as an efficient roadway marker. An automobile headlight quickly picks up the broad white ribbon of fence along the way, and the driver is both warned and protected.

Continued on Next Page

3. **Repaired Easily:** If fence fabric is seriously damaged, replace with new section between posts. One man can do this easily and quickly.

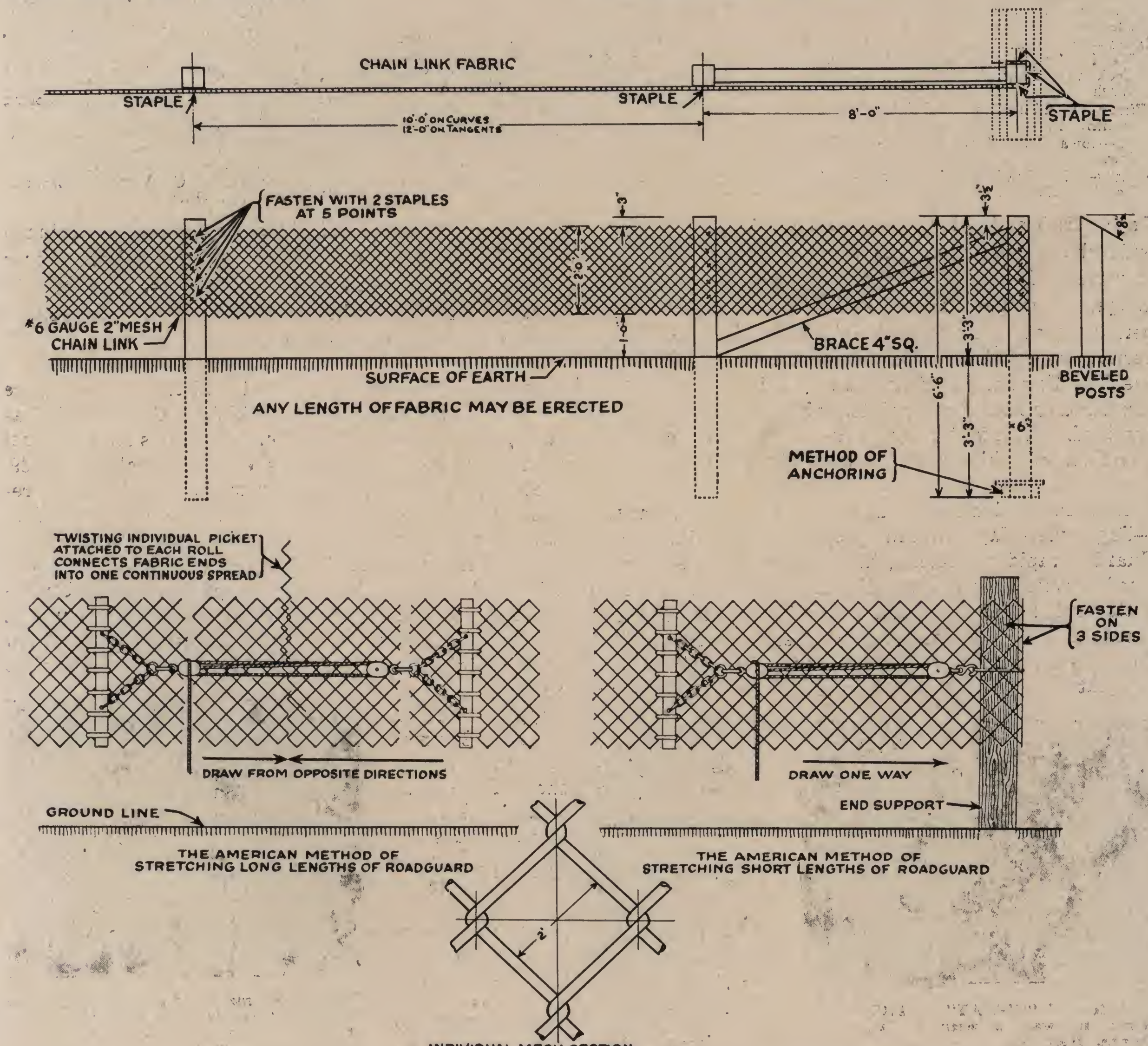
4. **Saving on Posts:** American Life Net is adapted to any kind of post-wood, concrete or steel. The strength and elasticity of the wire makes the cheaper wooden posts quite as practical as the more expensive posts.

5. **Stops Surely and Quickly:** The shock of impact is taken up quickly, but is so cushioned as to prevent the terriffic jar which results when a car strikes other types of highway guards.

6. **It Lasts Longer:** Wire is always safe and is easy to see. It cannot burn or rot. Extra heavy coat of galvanizing and paint stops damage through rust or corrosion. There is little or no upkeep expense.

Experience: For twenty-five years the American Wire Fence Company has enjoyed the confidence of engineers, manufacturers, and fence users everywhere.

Co-operative Service: Authoritative data and service relating to both highway protection and reinforcing will be furnished promptly upon request. Representatives are maintained in all parts of the country, and their service is offered without obligation to state and highway engineers and commissioners and to the contractors who supply highway materials.



PAGE STEEL AND WIRE COMPANY

Bridgeport, Connecticut

Distributors of "Hi-Way" Guard

(Reg. U. S. Pat. Off.)

District Offices: Chicago New York Pittsburgh San Francisco

Distributed for the Page Steel and Wire Co., associate company of the American Chain Company, Inc., Bridgeport, Conn., by the following companies:

Alabama, Mississippi, Northern Georgia, South Carolina—Dixie Culvert and Metal Co., Atlanta, Ga.

Arkansas—Dixie Culvert Mfg. Co., Foot E. 9th St., Little Rock, Ark.

California, Arizona, Nevada—California Corrugated Culvert Co., West Berkeley, Calif.

Colorado, Montana, Wyoming—The R. Hardesty Mfg. Co., Denver Colorado.

Connecticut, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island—New England Metal Culvert Co., Palmer, Mass.

Florida, Southern Georgia—The Dixie Culvert & Metal Co., Jacksonville, Florida.

Idaho—The Burnham Mfg. Company, Woods Cross, Utah, and Boise, Idaho; Spokane Culvert & Tank Co., Spokane, Wash.

Illinois—Merillat Road Supply Co., Monmouth, Ill.

Iowa—Iowa Pure Iron Co., Des Moines, Iowa.

Kansas—The Road Supply & Metal Co., Topeka, Kansas.

Louisiana—Louisiana Corrugated Culvert Co., 146 3rd St., Baton Rouge, La.

Maryland, District of Columbia & Delaware—Horace T. Potts & Co., 504 St. Paul St., Baltimore, Md.

Michigan—(less upper Peninsula) Barnes Wire Fence Company 10371 Northlawn Ave., Detroit, Michigan; U. S. Bridge and Culvert Co., Bay City, Michigan.

Upper Peninsula, Michigan—Boehck Machinery Co., 2404 Clybourne Ave., Milwaukee, Wis.

Minnesota—Lyle Culvert & Road Equipment Co., Minneapolis, Minn.

Missouri—Corrugated Culvert Co., Moberly, Missouri.

Nebraska—Nebraska Culvert & Mfg. Co., Wahoo, Neb.

New Jersey—Northern part: Brook Iron Works, Inc., 95 Church St., New York. Southern part: Horace T. Potts & Co., E. Erie Ave and D St., Philadelphia, Pa.

New Mexico—Western Metal Mfg. Co., El Paso, Texas.

New York and Pennsylvania—Highway Products & Mfg. Co., Elmira, N. Y.

North Carolina—General Equipment Co., Box 412 Dilworth Station, Charlotte, N. C.

North Dakota—Northwestern Sheet and Iron Works, Wahpeton, N. D.

Ohio—The Betz-Pierce Co., 2230 E. 9th St., Cleveland, Ohio.

Oklahoma—The Boardman Co., Oklahoma City, Okla.

Oregon, Alaska—Beall Pipe and Tank Corp., Portland, Oregon.

South Dakota—Western Material Co., 533 E. 14th St., Sioux Falls, S. D.

Tennessee—Tennessee Metal Culvert Co., Nashville, Tenn.

Texas—Western Metal Mfg. Co., Houston, Texas.

Utah—The Burnham Mfg. Co., Woods Cross, Utah.

Virginia—Virginia Metal Mfg. Co., Roanoke, Va.

Washington—Spokane Culvert & Tank Co., Spokane, Wash.

West Virginia—American Iron Roofing Co., Middletown, Ohio.

Wisconsin and Upper Peninsula of Michigan—Boehck Machinery Co., 2404 Clybourne Ave, Milwaukee, Wis.

Canada—Dominion Chain Co., Limited, Niagara Falls, Ontario.

TRADE MARK *America's first wire fence-1883*

ACCO AN ASSOCIATE COMPANY OF AMERICAN CHAIN COMPANY, Inc. *in business for Your Safety*

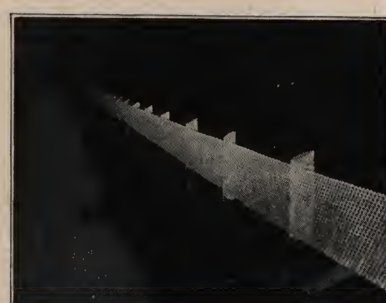
Page "Hi-Way" Guard is a special 24 in. wide chain link fabric, the strongest type of woven wire. Made of 2 in. mesh, No. 6 gauge, of copper bearing steel. Mesh is perfect square, with formed, flat links which permit the fabric to stretch smoothly and evenly. Galvanized after weaving with a super-heavy zinc coat—painted white when specified. At night, Page "Hi-Way" Guard becomes a ribbon of white that warns and protects.

Perfect Protection for Traffic: Rigid Guard endangers—Page "Hi-Way" Guard protects—Page "Hi-Way" Guard is rapidly replacing the old and obsolete type of wooden rails or other substitutes for safety. It is a better buffer than any other type of road guard. With horses and buggies traveling at speeds approximating 10 miles an hour a simple wooden guard rail proved adequate. But such obsolete rails are a menace to present traffic traveling at speeds ranging upwards from 30 miles an hour.

2,210 feet of "HI-WAY" GUARD on the scenic highway between Bellevue and Omaha, Nebraska.

Page "Hi-Way" Guard yields an impact—cushions the shock on car and posts—saves life — prevents property damage. After impact, the guard is quickly made taut by removing a picket or two with ordinary pliers. Loose pickets twist easily into loose ends of fabric, forming perfect unison. No special tools are needed.

Cars are Stopped with Little or No Damage by Elastic Page "Hi-Way" Guard—this has been proved repeatedly by exhaustive tests and by actual road use in every state in the Union. Catalog No. 169, available to any highway engineer or official upon request, tells in text and pictures of the results found in four separate tests ranged from laboratory strain loads or dropping a suspended weight 650 pounds from a height of 68 feet (the method approved by the Underwriters' Laboratories) to actual automobile impacts, the cars running from 22 to 38 miles an hour. Even at the highest speed (38 miles an hour) a Peerless coupe was stopped without damage. Summed up, the results show Page "Hi-Way" Guard stops cars at these speeds with little damage to the car and *complete safety to occupants.* We suggest you request the distributor nearest you to send you a copy.



Heavily galvanized and painted white, Page "Hi-Way" Guard is a broad ribbon of white at night that warns and protects—keeps cars on the highway.

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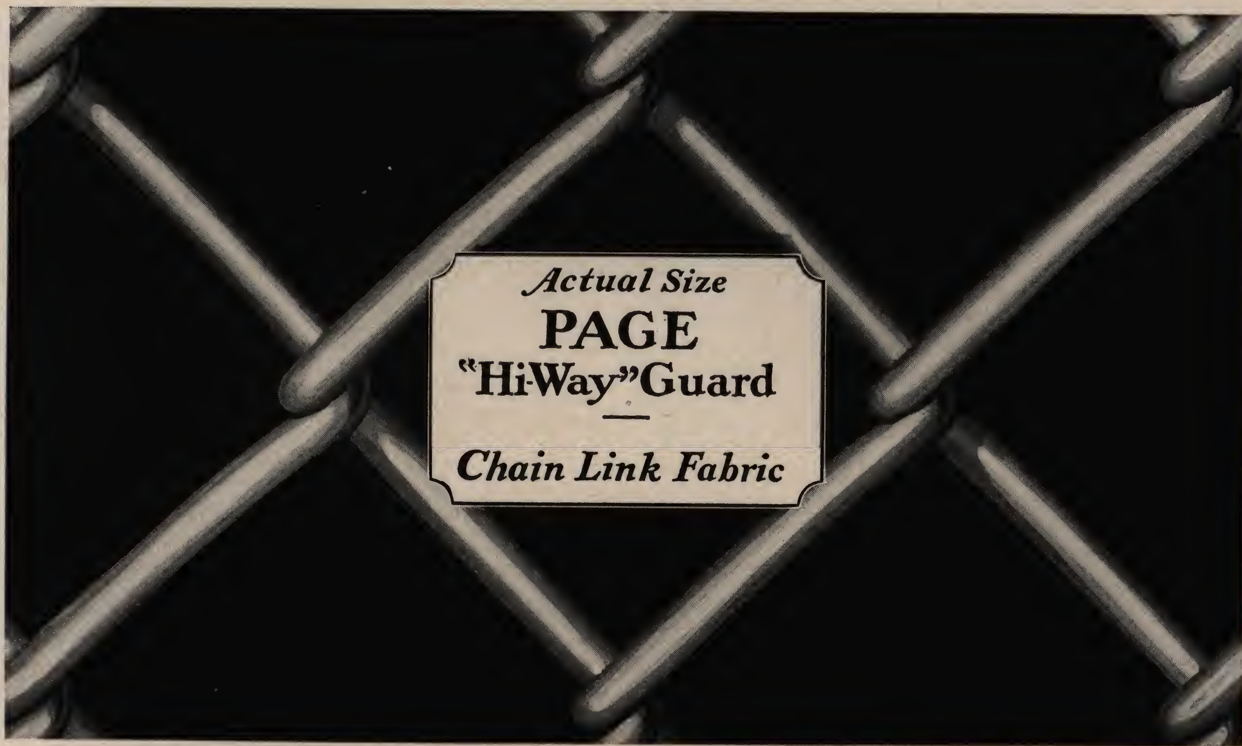


The exclusive Page flat mesh—actual size. This weave gives just the right balance between resilience and stiffness—the right margin of safety without excessive deformation.

In National Use: Page "Hi-Way" Guard is in service in every state in the union. It is being nationally specified or adopted as the most perfect form of road protection yet developed.

Quickly and Economically Erected: One truck carries several times as much "Hi-Way" Guard as wood rail. Because of strength and elasticity of fabric, posts may be set 12 ft. apart in tangents (10 ft. on curves), saving posts and installation cost. Fabric is quickly stretched and stapled to posts—no notching, drilling or fitting necessary. Ordinary labor, under a foreman's supervision, can perform the work perfectly and at low cost.

More Easily Repaired: It is after serious impact that Page fabric shows one of its greatest advantages. Correct picket formation makes joining of fabric ends with loose picket a simple matter. The loose picket picks up fabric ends unerringly. Simply start picket in place and twist it.

Shipping Information: Fabric is regularly furnished in 100 ft. continuous rolls, weighing approximately 280 lbs. packed for shipment. Burlapped when specified.

Compare the Mesh—Ask for Samples of Page Fabric: These advantages in mesh can make a great difference in the satisfactory service of chain link for road guard. Insist on comparing meshes before choosing the chain link guard rail you specify. Samples of Page Chain Link will be sent to highway officials and others interested. See nearest distributor on preceding page.

1,100 feet of Page "Hi-Way" Guard installed at entrance to Lakeville, Passaic County, N. J.

Page "Hi-Way" Guard eliminates danger spots along the Mohawk Trail in Massachusetts.

Installed by the Delaware State Highway Department on road between Wilmington and Newport.

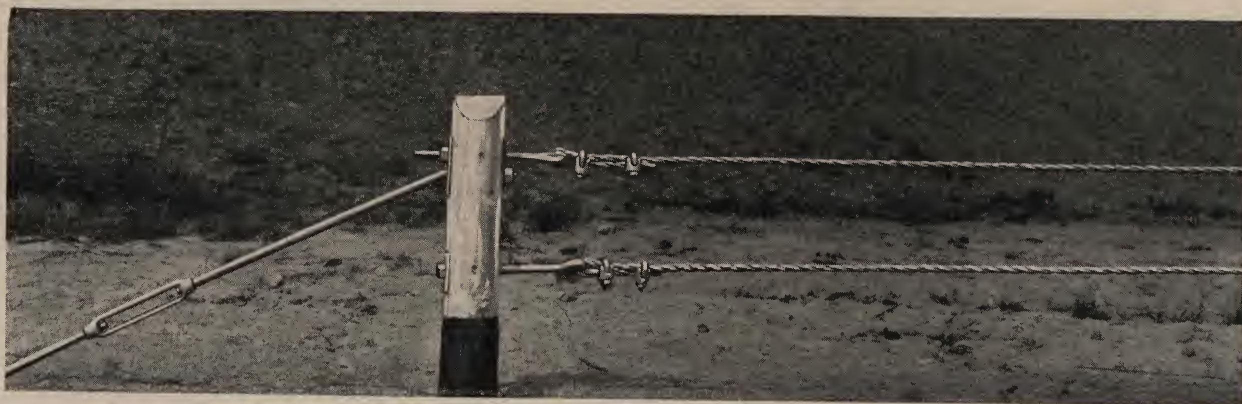
THE CLEVELAND HARDWARE COMPANY

4518 Lakeside Ave., Cleveland, Ohio

Manufacturers of Drop Forged Cable Guard Rail Fittings

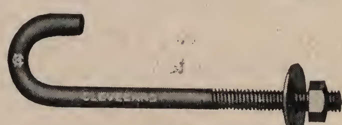
Products: Drop Forged Eye Bolts, Cable Retainer Bolts, Turnbuckles, Anchor Rods, Bearing Plates, Cable Clips and Thimbles.

Also a stock line of forgings for Truck Bodies, Wagons, Trailers and Automotive Equipment.
Special forgings made to specifications or blue print.



Specifications: Drop forged from the best quality open hearth steel and furnished hot galvanized or plain as desired. We have in our files specifications and blue prints for guard rail fittings as used in nearly all the various states. We will also make up to any specification desired when quantities warrant the special equipment.

Typical Patterns of Guard Rail Fittings:



Cable Hook Bolt
For holding cable against interior posts.

	Effective length	Stock
No. 591 A	7 in.	⅜ in.
H	8 in.	½ in.
K	8 in.	⅝ in.

Other lengths and sizes made up to specifications when quantities justify.

Galvanized or plain as desired.

Cable Eye Bolt
For end posts.

Some Standard Sizes of Eye Bolts

	Length overall	Stock	Dia. hole in Eye	Length thread
No. 590 B	8 in.	1 in.	1⅛ in.	4½ in.
F	15 in.	1 in.	1⅛ in.	5 in.
G	16 in.	1 in.	1⅛ in.	10 in.
H	18 in.	1 in.	1⅛ in.	12 in.
L	24 in.	1 in.	1⅛ in.	18 in.
P	48 in.	1 in.	1⅛ in.	3 in.
R	9 ft. 6 in.	1 in.	1⅛ in.	3 in.

Solid drop forged head, furnished with hex or square nuts as specified.

Eyebolts can also be made to specifications in other sizes and ¾ inch or ⅝ inch stock when quantities justify.

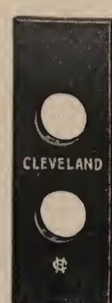
Galvanized or plain as desired.

Anchor Rods

For anchoring end posts to dead man.

Types of Anchor Rods vary considerably in different localities and we make them up to specifications. Standard turnbuckles furnished with from 6 inch to 12 inch takeup as ordered.

Galvanized or plain as desired.



589A—Anchor Rod and Eyebolt Plate

588A—Eyebolt Plate

Bearing plates on end posts for eye bolts and anchor rods. Galvanized or plain as desired.

No. 589A—Size 6x2x¼ in. Holes 1⅛ in.
No. 588A—Size 4x2x¼ in. Hole 1⅛ in.

Highway Maintenance

PATROL MAINTENANCE IN WISCONSIN.—Mr. J. T. Donaghey, Maintenance Engineer, Wisconsin Highway Commission, gives the following in Roads and Streets, regarding five years' experience in Wisconsin with this patrol system of maintenance.

Each patrolman enters into a written contract with the county and gives a bond in the amount of $500 for the faithful performance of the work and proper care of the tools and machinery entrusted to him. The contract is also subject to the approval of our division engineer.

On "team patrol sections" the patrolman must furnish a team and wagon satisfactory to the county, the county furnishing a light blade grader, road planer, plow, slip scraper and miscellaneous small tools. On "motor truck or tractor patrol sections" the county furnishes all the equipment.

The salaries paid on team patrol sections range from $140 to $165 per month; those on motor truck and tractor patrols average about $110 per month. The season extends from about April 1 to Dec. 1, and from Dec. 1 to April 1 the patrolman agrees to work when requested at a fixed rate per hour.

The "team patrol sections" average about 6 2/3 miles each, and as a rule are confined to earth road sections and those gravel sections that carry light traffic. We have few tractor patrol sections. They average about 12 miles in length and are generally confined to earth roads but are sometimes preferable on heavy traffic gravel roads where heavy maintenance equipment is necessary. Motor truck patrol sections average about 18 miles, and are economical only on heavy traffic roads where heavy maintenance equipment is necessary and where new material must be hauled regularly, on surface treated stone or gravel, and for work of concrete surfacings.

Maintenance Costs (State Trunk Highways).—The 1917 legislature provided for a 5,000 mile State Trunk Highway System, which the legislature of 1919 increased to 7,500 miles.

Table I shows the actual miles maintained by patrol methods each year, the number of patrol sections, the salary paid patrolmen, the patrol maintenance cost of each type per mile, and the amount expended per mile out of maintenance funds for "betterments." "Betterments" consist of widening the road and providing drainage with heavy blade grader work, light resurfacing, new culverts, and the cost of marking and signing the system.

Maintenance of County Truck Highways.—During the first month of patrol maintenance in Wisconsin the actual driving conditions were improved far beyond the expectations of the most optimistic friends of patrol maintenance. Table II shows the miles of county trunk highways taken over for maintenance each year by the several county boards, number of patrolmen employed, salary, cost of marking and signing, and total expenditures.

The above total expenditures average $214 per mile per year.

Table II bears out our original ideas and proves to us, at least, that the plan of operating through the counties has resulted in local demands for more roads to be maintained each year by patrol methods and consequently a much greater mileage of patrolled roads. In addition to the 7,500 mile state trunk system, we now have a 9,880 mile county trunk system, making a total of 17,380 miles of well-maintained roads. This gives more than 80 per cent of our population direct service, and brings patrolled roads within two miles of the remaining 20 per cent.

Results Obtained.—The "Wisconsin Idea" from the very beginning has been to "serve traffic." The patrol maintenance plan adopted in 1918, improved upon from year to year, and extended to include additional county highways each year, is certainly accomplishing its purpose.

After five years of patrol maintenance we find that the following conditions prevail:

(1) Every town, city or village in the state is on a well maintained and marked highway.

(2) Traffic is distributed over a large mileage, reducing congestion on many highways.

(3) The average speed of traffic has been increased at least ten miles per hour, resulting in time saving beyond computation.

(4) Night driving is safe and practical and our traffic census shows a marked increase each year in night traffic. Prior to five years ago, no sane person would think of driving from Milwaukee to our northern lake district during the night (300 miles), while now the practice is becoming very common and popular.

(5) Prosperity immediately becomes noticeable. The farmers along such routes soon vie with each other in promoting neatness in their road fences, farm buildings and entrances.

(6) Last, but not least, is the tourist, and our definition of a "tourist" is any person using our highways for pleasure, whether residents of Wisconsin or not. They tell us that we have the best maintained and marked highway system in the world. We realize that nature has provided Wisconsin with scenic features in abundance; nevertheless, the tourist today would not be with us if our highways did not make traveling by motor car a pleasure. It is extremely difficult to estimate the total amount spent in Wisconsin by tourists. From the most accurate data available we are confident that it now exceeds $100,000,000 annually.

Table I—Maintenance Costs State Trunk Highways

Year	1920	1921	*1922
Actual miles maintained	7,234.0	7,260.4	7,458.59
No. patrol sections	791	911	940
Monthly salary team patrol	$ 165.00	$ 155.00	$ 150.00
Monthly salary motor patrol	125.00	115.00	100.00
Patrol maintenance cost per mile:			
Earth	187.24	196.21	186.40
Gravel	184.68	193.85	183.25
Stone and gravel surface treated	706.11	682.23	671.84
†Concrete	220.18	322.21	311.85
Cost patrol maintenance	1,220,535	1,326.927	1,355,900
Cost of betterments	756,474	1,028,976	952,850
Cost of marking and signing	28,820	20,462	41,250
Total expenditures	2,005,829	2,381,413	2,350,000

The above total expenditures average $278.00 per mile per year.

*Final costs will vary somewhat from figures shown, as the season is not complete at this date.

†Annual costs include all shoulder maintenance, which runs high on all surfacings less than 18 feet.

Table II—Data on County Trunk Highway Maintenance

Year	1920	1921	1922
Miles maintained	7,743	8.980	9,885
No. of patrolmen	970	1,123	1.236
Average monthly salary of pa-patrolmen	$ 160	$ 150	$ 145
Cost of maintenance	1,435,527	1,867,615	2,279,804
Cost of marking and signing	9.300	8,100	11,000
Total expenditure	1,444,827	1,875,715	2,290,804

The Future of Patrol Maintenance.—We are satisfied with the progress made and the results obtained through our patrol maintenance system, but not contented. Our patrol maintenance has improved each year and will continue to improve. The surface has only been scratched insofar as marking and signing is concerned.

We expect local sentiment to continue to develop from year to year. We hope to increase our state trunk highway system until the counties are able to take over all the main and important town roads that serve county traffic generally. We expect that within five years the counties will be maintaining 20,000 miles in addition to the State Trunk System, making in all about 40 per cent of our total road mileage.

The local authorities will never adequately maintain the roads they use daily, and if the town roads are ever to be improved, they must be taken over by a larger unit of government. We are optimistic enough to feel that in the not too distant future the counties will take over all of the important local town roads and apply patrol maintenance, believing this to be the only practical solution of the town road problem.

The time may come when we will favor direct state maintenance. However, the thorough co-operation of the county officials in actual charge of maintenance and the sentiment developed by them locally for additional patroled roads and road improvement in general, confirms our original opinion that the co-operative plan of maintenance would result in the greatest good to the greatest number in Wisconsin.

COST OF ROAD PATROL BY TEAM AND TRUCK. —Mr. W. C. Davidson, District Engineer, New Mexico Highway Department, gives the following in *Roads and Streets:*

The Chaves-Lincoln County, New Mexico, team patrol covers all of Road No. 13 between Roswell and Carrizozo, except the 16½ mile section between Picacho Hill and Hondo (that portion of the road covered by present construction of F. A. P. No. 82), and all of Road No. 16 between Hondo and the Mescalero Indian Reservation, approximately a total of 110 miles.

This patrol is divided into five sections or sub-patrols of an average of 22 miles each.

Chaves County truck patrol covers all of Road No. 18 from Roswell to the Roosevelt County line at Kenna, all of Road 13 from Roswell east to the Lea County line near Cap Rock, and that portion of Road No. 2 from Roswell to Hagerman; making an approximate total mileage of 139. This patrol is divided into two sections or sub-patrols of 65 miles and 74 miles to each section.

Topography and Soil Conditions.—The Chaves-Lincoln County team patrol covers a hilly and mountainous country with a large percentage of hillside and mountainside construction where heavy rock conditions are encountered and where there is a scarcity of soil for roadbed purposes. Surfacing material, however, is rather plentiful in the nature of arroyo gravel and semi-gravel soil.

The roads of the Chaves County truck patrol lie in the Pecos Valley and on the adjacent uplands and plains to the east and northeast. No mountain construction, but some side hill construction, mainly the ten-mile section along Railroad Mountain on Road No. 18. The soil conditions of this county are more favorable to grading, dragging and other roadbed maintenance than found in Chaves-Lincoln County team patrol roads.

Types of Road Represented

Chaves-Lincoln County team patrol—	Miles
Federal Aid mileage	14.85
Forest Aid mileage	42.90
Non-Federal Aid nor Forest Aid mileage	52.25
Total	110.00

Of this mileage the type of construction are approximately as follows:

	Miles
Gravel or crushed rock surfaced	12.
Semi-gravel plating (F. A. P. No. 20-B)	5.09
Selected soil or semi-gravel plating (Forest Aid Project, Hondo-Mescalero)	26.
Graded earth or natural soil road	66.91
Total	110.00

Chaves County Truck Patrol

	Miles
Federal Aid mileage	53.
Non-Federal Aid mileage	86.
Total	139.00

Of this mileage the types of construction are approximately as follows:

	Miles
Gravel surfaced	46.51
Caliche surfaced	3.24
Crushed rock surfaced	3.25
Graded earth or natural soil road	86.00
Total	139.00

(The 10 miles of F. A. P. No. 103 is considered above as graded earth or natural soil road.)

Widths and Sections.—Chaves-Lincoln County team patrol: On this patrol there are 65 miles of 2-way or 2-ditch grading, and 45 miles of 1-way or side hill grading. The average width of grade over the 110 miles is 18 ft.

Chaves County truck patrol: On this patrol there are 53 miles of Federal Aid constructed roads of the standard width of 24 ft., 2-ditch grading. Of the 86 miles of non-Federal Aid road there are 76 miles of 2-way or 2-ditch grading with an average width of 22 ft. grade. There are 10 miles of side hill or 1-way grading; this along Railroad Mountain on Road No. 18. The average width of this 1-way grade is 20 ft.

Personnel and Equipment.—Chaves-Lincoln County team patrol: This organization consists of one patrol superintendent, five foremen of sub-patrols, and the following equipment to each sub-patrol: One grader, one drag, one fresno, one plow, and the necessary smaller tools for general maintenance work. All of this equipment of sizes suitable to use by single team power.

Chaves County truck patrol: This organization consists of two patrol foremen, two truck drivers, extra laborers when necessary and the following equipment to each section or sub-patrol: One Nash Quad truck, with reserve of extra trucks when emergency needs demand; one road grader, one highway maintainer, two heavy duty road drags, one plow and the necessary hand tools suited to use for general maintenance work.

Costs.—Total expenditures during the five months period:

Chaves-Lincoln County team patrol	$5,554.55
Chaves County truck patrol	5,495.22

Of the former cost, $115.17 was expended as foremen's salary and expenses prior to September 1st; $586.58 for bridge lumber; and $152.00 for labor on bridge repairs.

Of the Chaves County truck patrol cost, $1,179.00 was expended for items other than regular maintenance. These items represent special work done at Acme Draw Bridge costing $204.00; the payment for 500 cu. yd. of crushed stone bought and stored for future use on F. A. P. No. 103 costing $425.00; also snow removal work performed during December on the main roads of the County, costing $550.00.

Allowing for these deductions, the net expenditure for the items of general maintenance during the five months' period are:

Chaves-Lincoln County team patrol	$4,700.80
Chaves County truck patrol	4,316.22

Average maintenance expenditure per month:

Chaves-Lincoln County team patrol	$940.16
Chaves County truck patrol	863.24

Average maintenance cost per mile per month:

Chaves-Lincoln County team patrol	$8.55
Chaves County truck patrol	6.69

(Mileage of Chaves County truck patrol figured at 129 allowance having been made for the ten-mile section covered by F. A. P. No. 103, which was unfinished and not maintained during this comparative period.)

Average cost per mile per year based on the above figures:

Chaves-Lincoln County team patrol	$102.60
Chaves County truck patrol	80.28

As a further comparative cost, the following reproduction from Lincoln County portion of report of this district shows the following costs in Lincoln County during the nine months of the year during which the Lincoln County roads were maintained by truck method.

"From the begining of the fiscal year until the tenth of September, all maintenance in this county was taken care of by a 2-man crew with Nash Quad truck, a grader, drags and small tools. There are 106 miles of road under maintenance in this county and the total amount expended for truck maintenance was $7,100, which is an average of $7.50 per month per mile.

"The roads of this county were placed under team patrol maintenance on Sept. 10th, replacing truck patrol maintenance. Four patrols have been allotted 88 miles of road, or 22 miles to each patrol. Each patrol unit consists of one man and team, light patrol grader, 3½ ft. fresno, road drag, plow, tent and hand tools. The cost of equipment of each patrol was approximately $350. The sum of $2,300 has been expended on this 88 miles at the close of the year, which is $8.75 per mile per month. (This does not include cost of equipment.)

"Unusually heavy rains, which have fallen since the adoption of team maintenance, have handicapped the effectiveness of this method to some extent, thereby making it difficult to arrive at an impartial comparison at this time of the costs and results of this type of maintenance with truck maintenance.

"Lincoln County—Mileage maintained 106:
Pure Maintenance:

1. Dragging (565 miles)	$1,300
2. Regrading (115 miles)	1,800
3. Miscellaneous general repair for year	1,500
4. Team maintenance from Sept. 10 to Nov. 30, consisting of dragging, regarding and general repairs over 88 miles of road	2,300
	$6,900

Betterment Work:

1. Surfacing and resurfacing (3,000 cu. yds. material used)	$2,000
2. Bridge, culvert and spillway repairs	500
	$2,500
Total maintenance expenditures	9,400

Average annual cost per mile, approximately $88.50.

Average monthly mileage cost of maintenance:

By truck method	$7.50
By team method	8.75

The above figures show that the team method of maintenance is approximately 25 per cent higher than truck methods, assuming that results are equal. Of this question the condition of the roads will have to reveal the more efficient method.

In arriving at the above cost analysis, no machinery cost nor depreciation has been figured into the maintenance cost of Chaves-Lincoln County team patrol, while in the Chaves County expenditures the usual depreciation and some rental on equipment has been included in the cost. With this item taken into consideration, the team method cost would result approximately 33 1/3 per cent higher than the truck methods.

Conclusions.—The difficulty of team maintenance has been our inability to cover the patrol quickly after rainfall. The result was that the roads were left in a rough and choppy condition which could not be eliminated with the light team maintenance equipment. The distinct advantage of motor maintenance is speed plus weight, which show immediate results without continued application.

Careful observation of team maintenance extending over a period of several months, has revealed this fact: That for a long period after moisture the greater part of the patrol was rough on account of the slowness with which the team outfits gradually covered the mileage. Short sections for two or three miles each side of camp headquarters were found to be in excellent condition within two or three days following a season of moisture. This proved that where a team patrol was confined to a short mileage, satisfactory results were obtained. The cost, however, for this short mileage was prohibitive. Experience seems to bear out this conclusion: That a team patrol can successfully handle from 6 to 8 miles of road, but no more. This results in a cost entirely prohibitive with present allotment of maintenance funds.

When the road from Roswell west to Picacho Hill was turned over to team maintenance it was generally in a smooth condition throughout. Its present condition, while not extremely rough and chuggy, is far from smooth and the motor car is inclined to chatter, due to numerous small corrugations. The heavier motor type maintenance equipment was found to be inadequate.

The high type road (such as Federal Aid projects) seems to have suffered most under team maintenance. No surfacing replacement has been possible on account of other maintenance operations. The equipment has been too light and as a result the projects are becoming wavy and out of section.

Somewhat better results have been obtained along the Bonita and Ruidoso Creeks. There are two reasons for this:

(1) Stock water and feed are available at numerous places along the patrol, and therefore the patrolman is not compelled to return to his camp base each night.

(2) There, roads are narrow and maintenance reduced to about half that of the standard width road. Also the roads, being side hill located, call for only one-way maintenance, which is by far the simplest and cheapest type of maintenance.

Nothing has been accomplished with teams, even under these most favorable conditions, that could not have been improved upon, both as to cost and character of work performed, with the light motor equipment now in use throughout the state.

DRAGGING COSTS, TRUCK vs. TEAM.—In 1927, according to Mr. A. L. Burridge, Division Engineer, Michigan State Highway Department, the cost of dragging with trucks and heavy equipment on 117 mi. of road having a 20-ft. gravel surface and carrying approximately 1,000 vehicles per day during the dragging season was $170.95 per mi. To completely cover a 20-ft. width would require two round trips with teams and patrol graders. Assuming a team could make two round trips a day on a 5-mi. section at a cost of $7.50 per day, the cost per year, counting 200 dragging days, which is a conservative estimate for Michigan, would be $1,500, or $300 per mi. The cost of doing this class of work with antiquated equipment can therefore be estimated as costing almost twice as much as with modern equipment. It seems ridiculous now to think that a highway organization would have ever used such expensive and inefficient a method as horse-drawn dragging equipment, however, no criticism should ever be directed to officials who used this class of equipment. It was the best available at the time and served a useful purpose in the evolution of modern equipment.

Cost of Road Maintenance in Wyoming.—The following was taken from Wyoming Roads:

Each district has a maintenance foreman experienced in all classes of maintenance work. His duties are to supervise all maintenance work in the district, to inspect all structures regularly and thoroughly, to provide warning of danger until it can be removed, to see that all men under him take proper care of their equipment, to make emergency repairs to equipment that his men are unable to make and above all to instruct new men in his employ.

To sum up, we have as follows:

		Per cent
Surface maintenance	$144.00	34.8
Ditch maintenance	12.00	2.9
Culvert maintenance	15.00	3.6
Structure maintenance	12.00	2.9
Reshouldering	25.00	6.0
Replacing surfacing	180.00	43.4
Sign maintenance	3.00	.7
Total	$391.00	
Supervision 6 per cent	23.46	5.7
Total one mile maintenance one year	$414.46	100.0

The above does not take into account snow removal in the winter or washout or accidents that might be the cause of additional expense, but may be taken as an average on those routes having a traffic which does not exceed 500 vehicles per day.

METHODS AND COST OF GRAVEL ROAD MAINTENANCE IN MAINE.—Mr. Paul D. Sargent, Chief Engineer, Maine State Highway Commission, gives the following in *Roads and Streets:*

In discussing this topic it appears to me to be necessary to assume for purposes of discussion that we are talking about the maintenance of some particular kind of gravel road. Therefore, let us assume that the road to be maintained has been thoroughly and properly constructed, with good side ditches, sufficient culverts and off-take ditches, and with proper attention given to any weak foundation conditions discovered in the sub-grade; that is to say, that carefully constructed stone base has been laid over such location and that the whole road has received a surfacing of gravel, preferably laid in two courses, so as to make a finished road having a surface of 8 in. of compacted gravel at least 16 ft. in width.

The method of maintaining such a road and its cost will depend largely on the amount of traffic which the road carries.

Length of Patrol Sections.—With a traffic less than 400 vehicles per 12 hour day, of which 90 to 95 per cent are motor driven, such a road can be best maintained by the patrol method. It is possible for a man with one horse, weighing, say, 1,600 lb., with a cart, a light drag and small tools, to keep a fairly good surface on a gravel road under these conditions. Two horses are preferable, but this will increase the cost just the amount paid for the extra horse. An average of 8½ miles can be taken care of, provided some extra help is allowed for drawing gravel for necessary replacing of surface material worn off and blown and washed off the road. This has been the average length of patrol sections in the State of Maine during the past eight years. Based on our experience, I am led to conclude that from 6 to 6½ miles would make about the right length of gravel road for one man to care for. Our finances have not permitted us to establish this length of patrol section.

Dragging.—The patrolman should see to it that the surface of the road is smooth at all times and free from loose rocks. The road should be dragged after every rain storm or heavy shower, and we have found that systematic dragging once or twice a week in dry weather will do more towards preserving a smooth surface and a good riding road than any other one thing.

We have developed a special style of light drag for either one or two horses. The front part of the drag, which carries a steel cutting edge, is a hard wood plank 2x7 in., set on edge. Connected with this by two pieces of steel especially shaped and 20 in. to the rear are two 2x8 hardwood planks laid flat with the forward edge beveled from the bottom up to smooth the surface behind the cutting edge. The one horse drag will weigh about 200 lb. and the driver stands upon it when dragging. It is drawn at an angle of 60° with the center line of the road and will scrape a little more than 5 ft. in width. For two horses the drag is built 1 ft. longer so it will scrape 1 ft. more in width.

We are working more and more into the use of light graders and if we could afford it would equip each patrolman with one.

After dragging is completed, if loose stones have been brought to the center of the road they should be raked and cleaned up and used to widen shoulders or stored at convenient locations for use in strengthening weak places which may develop in the spring.

The patrolman will see that ditches, culverts and off-take ditches are kept clear for the free flow of water and that bushes are trimmed back so as not to interfere with traffic, especially at curves or at blind corners.

Replacing Lost Gravel.—Provision must be made for replacing the gravel worn from the surface of the road. The patrolman can do some of this work, especially if gravel pits are located adjacent to the work or if gravel for this purpose has been delivered in stock piles along the road. The most satisfactory method of replacing gravel surface is by the employment of extra men and teams working under the direction of the patrolman, or by using a floating truck gang similar to a ballast crew in railroad maintenance work. Whether teams or trucks are employed will depend upon local conditions, such as availability of teams and labor and length of haul from pit to road. It does not appear to be economical to move gravel much over 2 miles with horses, generally speaking, and in the work of our own Department we have moved gravel a much less distance than 2 miles by trucks more economically than it could be done with teams. This has been true on hauls as short as ¼ to ½ mile. In these cases loading has been done with machinery and the work so planned that trucks do not have to lose any time except when actually loading.

One advantage in using trucks for resurfacing is that with dump bodies and properly constructed tail gates the gravel is spread as it is deposited on the road and one man with a rake can make all the adjustment necessary to produce a smooth surface. In adding any gravel for resurfacing, we generally put not over 2 in. in depth and it is spread 8, 10 or 12 ft. wide, as the road requires. It is our practice to screen all gravel for resurfacing through a 1¼ in. mesh screen.

In the maintenance of plain gravel surfaces we have found it advantageous to keep a covering of loose clean gravel over the middle 10 ft. of a well bonded surface. This material should be not more than 1 in. in depth nor less than ¼ in. The lighter the traffic the greater the thickness of loose material we can use. When traffic approaches 400 per 12 hour day corrugations appear and they will be as deep as the loose material. For that reason we reduce the depth of loose material as traffic increases. This is accomplished by pushing part of the loose material off the crown of the road or by adding enough clay to bond a portion of the loose material to the tightly bound surface. The latter is a delicate operation and should not be attempted by a novice.

Removing Corrugations.—Without a covering of loose material on a tightly bound surface pot holes will appear under a daily traffic of 400. Light corrugations are less objectionable than a surface full of pot holes or depressions, hence our light cover. The best method

of patching is to fill them with gravel during or just after a rain storm, when the holes are full of water so that the material will bond. If filled during dry weather the gravel will be immediately pushed out by vehicles.

A badly corrugated surface should be planed from the center towards the sides to the depth of the corrugations. After this is completed, bring back the material from the sides and spread evenly over the surface.

Costs.—The cost of maintenance of gravel roads as above outlined has been over a series of 8 years $100 per mile plus the patrolman's wages. For the past few years we have paid for a man, two horses, cart, drag and tools $6 per day of 9 hours, or $150 a month. Patrolmen average to work from April 15 to November 15, or a period of 7 months. This makes the cost of maintaining an 8½ mile section $1,900, or about $223 per mile per year. These figures are based on the employment of approximately 500 patrolmen each year for the last 8 years. If one horse is employed instead of two, the cost of the patrol outfit will be $1 per day less.

Surface Treatment.—When traffic reaches between 400 and 500 vehicles per 12 hour day, plain gravel surfaces will corrugate or ripple and as traffic increases beyond the 500 mark these corrugations become so pronounced that they are extremely disagreeable to ride over. Dragging, or better, scraping with a grader, will in a measure keep these corrugations down, but as long as the traffic holds up to the volume named scraping will have to be carried on continuously. The only satisfactory method we have developed for maintaining gravel roads under a volume of traffic exceeding 500 vehicles per 12 hour day is to surface treat with bituminous material. The State Highway Commission of Maine has been doing more or less of this work during the past 8 or 10 years and we have some sections of gravel road so treated which take a traffic of 6,000 vehicles per 12 hour day fairly satisfactorily. We have used refined tar products and various grades of asphaltic oil, but for the last 6 of 8 years we have used almost exclusively refined tar, falling within the specification T C-1—Tar for Cold Application—Bulletin 691, United States Department of Agriculture.

Practice in Surface Treatment.—Without detailing our early experiences, I may say that we have developed the following standard practice:

As early as we can get on the roads in the spring, that is, when the roads begin to settle and dry out after the frost has left them, we begin shaping with the road grader. The roads are carefully watched during the two or three weeks while they are settling and are shaped either with a drag or blade grader several times if necessary to have them settle with as true a contour as possible. The next stop in our surface treatment is to draw out sand, which is left on the shoulder of the road in piles of about a quarter of a yard every 25 ft. Generally speaking, we use about 80 yd. of sand to a mile for cover. We use less sand, however, on a brand new treatment than we do on retreatment. Sometimes as little as 50 yd. to a mile is used on the original treatment. Retreatments will take from 50 to 80 yd. per mile, as the tar has less opportunity to penetrate into the surface of the road. The next step is to clean the surface of the road of all loose material. If a pocket of sand, dust or stone is left on the surface we are absolutely sure to have the treatment break over that pocket in a short time after application. This cleaning is done by the use of a street sweeper behind a light truck and if further cleaning is necessary after the sweeper has finished this is done by men with push-brooms. Then comes the tar distributing gang, which is equipped with Kinney pressure distributors mounted on 3½-ton trucks. We have limited ourselves to this size of equipment because it is as heavy as our roads, generally speaking, will carry. We have a law which limits the gross weight of load to 9 tons, and I am free to say that one of these 600-gal. tanks filled with bituminous material will a little exceed the limit set up by statute for the gross weight of load. Under average conditions one tank truck will spread about 2,500 gal. of tar per day. Our practice is to tar one side of the road at a time and several days may elapse between the tarring of the first side and the tarring of the remainder of the road. Immediately after the tar is applied a light sanding is given. We put on just enough sand to fairly blot the bituminous material and keep it from running off the crown of the road to the edge. The surface is carefully watched for three or four days and if evidence of bleeding shows up spots where this occurs are treated with more sand. Sometimes after a treatment has been down for two or three weeks an extremely hot day will start a little bleeding. This is watched carefully by the patrolman and the same treatment of light sanding given.

Treatment of New Gravel Surfaces.—In the treatment of new gravel surfaces, that is, surfaces which have never received a treatment before, but which may have taken traffic anywhere from 2 to 4 or 5 years with an occasional resurfacing of gravel, we use not to exceed ½ gal. per sq. yd., and in more cases probably use 0.4 to 0.45 gal. per sq. yd. for the treatment. The amount of material depends upon the tightness of the surface. We have found that the smallest quantity of material we can use and get the surface covered gives us the best result. With a small quantity we never have trouble from rippling or waving of the surface, provided the gravel is in proper shape to receive the treatment when it is given, that is, thoroughly bonded and tight with no pockets of gravel, dust, or other loose material. We also find that surfaces which have received a small quantity of tar can be retreated for a longer time than surfaces which have been given a heavier treatment. Those which have received the heavier treatments will ripple and get out of shape, say in 2 or 3 or 4 years, while sections receiving a light treatment can be maintained without breaking up for a considerably longer time.

It must be borne in mind that the addition of the bituminous surface treatment to a gravel road does nothing but preserve the surface against disintegration from passing traffic. It does not materially strengthen the road in the sense that it will cause the road to take heavier loads than the gravel surface itself or the foundation upon which it is laid will sustain. Surface treatment will not supply or take the place of drainage.

Maintenance of Surface Treated Sections.—Our surface treated sections are kept under constant patrol maintenance. We patrol these roads with a light truck and two men and they are assigned sections anywhere from 12 to 18 miles long. Besides watching the bituminous surface and mending any small breaks that may occur—and we have these breaks occasionally—and patching the shoulders, these men also keep the dirt shoulders shaped by dragging, keep the gutters and culverts clear and do whatever other work is necessary. We supply about 3 bbl. of bituminous material like that with which the road is treated for each mile of surface. This material is mixed with sand and kept in stock piles. The mixing is usually done by hand and we use about 17 gal. of tar to a cu. yd. of sand. In a few instances we have used a small concrete mixer to prepare the tar and sand for patching and we have been able to use as little as 14 gal. to a yard of sand when the mixing is done in a concrete mixer. Patches are made by simply cleaning out the hole, throwing in the mixture of bituminous material and sand and patting it in with a shovel. Any bad breaks on the shoulders are repaired the same way.

Spring Breakups.—The most of our gravel treated surfaces do not remain intact over the spring period, a good deal of it breaks up. This is due to several causes. An open winter which allows the frost to penetrate deeply into the roadbed and allows traffic to run all winter long, or heavy traffic coming on these surfaces when the frost is leaving and the surfaces are soft, will break up and generally disintegrate the surfaces. This really is more or less of an advantage, because it obviates the necessity of breaking up these surfaces and we save just that much expense in getting the surface ready for subsequent treatments. I have in mind one section of gravel road which was surface treated during the summer and broke up the next spring.

Most everyone called it a good section of road, in fact many automobilists have referred to it as bituminous macadam and many of our citizens refer to our surface treated gravel roads as bituminous macadam roads, especially when they want to tell about a bituminous road the highway commission has built which has failed in the winter. The particular section I refer to was so bad during March that automobiles could not pass over it, or through it. For 4 or 5 miles this piece of road was literally a sea of mud for a period of about three weeks. Of course the surface treatment completely disappeared. We reshaped the road as it dried out and retreated it in the spring. It presented a good surface all through the summer and fall until it was covered with snow. It has since broken up each spring and has been thoroughly satisfactory in the summer after being reshaped and treated.

On the other hand, I have in mind one section of surface treated gravel road which is built on a sandy foundation where the drainage is perfect that has never broken up during the last 10 years. It gets a retreatment about every other year, maybe 1/6 or 1/7 gal., as the gang goes by, and during the intervening year it does not get treated. This particular section shows evidences of slight ripples. It is on our heaviest traveled line, where the snow leaves earliest in the spring and we have the most severe truck traffic in the state.

We have a good many sections of surface treated gravel roads which do not break up in the spring. The most of these sections get a retreatment each year. The second year the amount of tar which we have used has been from 3/10 to 1/3 gal. per sq. yd. For the third and fourth years the amount has run as light at ¼ gal., and in some instances 2/10. These surfaces are quite apt, however, after three or four retreatments to become ripply enough so as to be uncomfortable to ride over. This condition is due to a combination of reasons. One is that we may have as much as 1½ or 2 in. of tar penetration which becomes separated from the gravel road itself on account of the passage of heavy loads when the frost is coming out of the roads, and the whole roadbed is more or less soft. Where this tendency exists at all it is always more pronounced where the surface has received successive treatments than where only one or two treatments have been given.

Shaping the Road for New Treatment.—Each year we have to break up more or less of this kind of surface and get the road in shape for new treatment. The method used is about as follows: We take a section of road about 1,000 ft. long; it is broken up either by using a pressure scarifier on a steam roller or by using a heavy blade grader behind a truck or a roller and setting the blade so that it will do more of a plowing operation than a scraping one. The bituminous surface is in this way broken up into chunks anywhere from 2 in. to 2 or 3 ft. square. We next take a road grader and scrape this whole surface off to the shoulder of the road, then we plane the roadbed below to as true a surface longitudinally and transversely as possible. We then work back a portion of the bituminous bound material from the shoulder, distributing it over the surface. In this distributing operation the bituminous bound gravel is broken up more or less into small chunks. We then leave the road for two or three days for traffic, which materially helps in further breaking up these pieces of bituminous bound gravel, then the road grader is brought on and further working of the surface is given just by pushing the chunks around and pulling in more from the sides. By watching the surface carefully and using the road grader every two or three days we have been able to get the surface back into reasonably smooth condition. It presents more or less of a mottled or mosaic appearance. Gravel which has been covered with the bituminous material has lost its binding property and it is necessary quite often to add a bit of good binding material here and there to complete the bonding of the surface. This binding material is used sparingly. We do not intend to have enough to leave any appreciable amount of dust to be swept off prior to the new treatment. As soon as we have the surface in shape we plan to immediately give it a new application of tar. We find that one of these surfaces broken up and reshaped as just described is very hard to keep in true contour under traffic and if it is allowed to go say two weeks we may have to break it up and rebond it before the tar surface treatment is given, else it would be so uneven as to be a bad riding road all through the season.

Experience has shown that one of these old tar surfaces can be scarified and broken up more easily when the temperature is between 60 and 70° F. than during cooler weather. Good warm, sunny weather also materially assists in breaking up the chunks of tarred gravel which are left on the surface of the road.

Effect of Dampness on Treatment.—One thing we have satisfied ourselves upon is the fact that we cannot successfully apply tar surface treatment on a wet road or on a damp road. We have also had the experience of rain falling within two or three hours after tar has been applied and before the tar has taken any set, and with a traffic say of 100 to 200 cars per hour this has resulted in making a mushy surface which it is practically impossible to true up and make satisfactory. We have practically come to the conclusion that when this condition prevails we would do better to scrape the new tar surface right off and put on a new application of tar. We will spend more money in patching the surface which is laid under these conditions than it would cost to replace the surface, and such surface after patching has never been satisfactory.

Cost of Surface Treatment.—During a four year period our surface treatment work, plus the cost of patrol maintenance, for a season of 8 months has averaged to cost $1,000 per mile. We estimate sand to cost us an average of $2.00 per cu. yd. delivered in piles alongside the road. Tar costs us $0.12 per gal. in tank cars delivered on the nearest railroad siding. We figure the cost of applying the tar at $0.02 per gal. Sanding costs about $0.75 per cu. yd. of sand. Using say 4,000 gal. of tar per mile gives us a cost for tar on the roadbed of $560; 80 yd. of sand will cost $160, applying the same $60, making the cost of the tar treatment covered with sand $780.

The average cost of shaping and getting the surface ready for treatment in the early spring would be about $25 per mile. We use ordinarily a 2-ton truck to draw the road machine. The truck rental would be $10 per day, the driver's pay $4 and a helper $3.25. The rental of the road grader is figured at $2 per day. Gas and oil will run from $5 to $6 a day. This outfit will average to smooth 4 miles per day. Usually on the first smoothing we make about 4 round trips per mile. On subsequent smoothings possibly 2 trips will do; it all depends upon the condition of the road when it is smoothed and the subsequent condition of rain and settling of the road.

For sweeping we use a mechanical sweeper drawn by a light truck, a ¾-ton or a 1-ton truck. We usually make 4 trips with the sweeper, and this outfit will sweep about 2 miles per day, as we can only run the sweeper about 3 miles per hour. The expense for sweeping would run about as follows: Truck rental $5, oil and gas $2, driver $4, helper $3.25, rental of sweeper $2, making a total of $16.25, an expense of sweeping 2 miles of road of $8.12 per mile.

The balance of the $1,000 is paid for patroling the road through the season. The usual patrol gang on bituminous surface treated gravel roads is a patrolman with a 1-ton truck and helper. According to the amount of traffic and the condition of the road, this outfit will cover anywhere from 12 to 18 miles of road. The outfit costs $14.25 per day, made up as follows:

Rental of 1-ton truck $5, gas and oil $2, patrolman, who drives the truck $4, and helper $3.25.

These gangs work an average of 200 days per year, so if the patrol section was 14¼ miles long the average cost per mile would be just $200.

Based on the figures given above, this would show a maintenance cost of $1,014 per mile per year. I have said that on new roads we use ½ gal. of tar per sq. yd. That will increase the cost $140 per mile over the figures already given.

Where it is necessary to scarify or break up the old bituminous surface, we run into a considerably larger expense for preparing the surface than indicated above. I think I have given enough explanation, however, to show that the average cost is very close to $1,000 per mile per year.

Use of Tar Priming Coat.—There is one point that I neglected to mention, and that is that quite often in making an original treatment if traffic is running fairly heavy and it will take us 6 or 8 days to treat the section we are working upon, we will slide over the road with a priming coat of tar material, using 2/10 to ¼ gal. per sq. yd., the quantity depending upon the tightness of the surface. This will hold our surface in perfect condition under traffic for a week or ten days. We immediately apply the balance of the quantity, sand, and finish up the job. We have also come to the conclusion that it would be good practice to do the priming everywhere on new surfaces. It gives a better penetration of the bituminous material, besides holding the surface in proper contour until the treatment can be completed.

Use of Calcium Chloride.—I want to say just a word about the use of calcium chloride as a dust preventive. When traffic gets above 200 or 300 per day the dust not only becomes a nuisance to travel but many times is a positive danger, to say nothing of the fact that the road surface is being moved from its proper location to adjacent land. The use of calcium chloride in quantity from 1 lb. to 1¼ lb. per sq. yd. will hold the surface material, keep it on the road, and will prevent dust. This material is spread directly on the surface of the road, preferably with a lime sower, which will give a fairly uniform distribution. It may be spread, however, with shovels from drums or bags in which it is shaped and if care is exercised a quite uniform application will result.

With calcium chloride costing us an average of $30 per ton f. o. b. nearest railroad station, we figure the cost of this treatment, 18 ft. wide, at about $275 per mile applied. A surface so treated must be dragged occasionally to keep it smooth. Ripples will occur on the surface of a road treated as readily as on a plain gravel surface when the traffic reaches 500 per day.

Maintenance Cost of Two Typical Gravel Roads.—The following are the records of traffic and cost of maintenance on two typical gravel roads in Maine:

Highway "I"—Waterville to Bangor, 55 Miles

Year	Average Traffic	Average Maintenance Cost Per Mile
1916	----	$ 120.89
1917	265	346.75
1918	240	490.15
1919	452	429.82
1920	490	498.93
1921	635	738.27*
1922	756	1,476.37**
1923	948	1,971.61**

Highway "D"—Woolwich to Rockland, 43 Miles

Year	Average Traffic	Average Maintenance Cost Per Mile
1916	375	$ 155.82
1917	355	365.82
1918	467	395.49
1919	666	524.38
1920	623	828.09
1921	704	819.31*
1922	782	1,354.13**
1923	778	1,322.37**

*Calcium chloride.
**Tar.

TRACTOR PATROL MAINTENANCE OF GRAVEL ROADS.—J. H. Dennis, Road Engineer, Genesee County, Michigan, gives the following in *Roads and Streets:*

Genesee County has 442 miles of gravel-surfaced roads including about 13 miles of stone or slag base. Ordinarily about 30 full-time patrolmen and six or eight part-time patrolmen are employed, the length of patrol sections varying from two to 30 miles.

Thirteen tractors were used during part of one season, the balance of the work being done by teams. The miles of road maintained by each tractor varied from 7½ miles to 29 miles depending, of course, on the amount of traffic, character of gravel, or other local conditions, with an average mileage per tractor of a little better than 13.

Twelve of the tractors were placed on roads having an average traffic of about 600 vehicles per day. The 13th tractor was placed in charge of 29 miles of fairly light traffic roads.

The class of work done by the tractors proved very satisfactory. There was no question but what more material can be handled per trip by tractor than with the use of a team and grader. Weather conditions do not affect the operation of tractors. There is always a tendency in hot weather for teams to slow down, either a slower pace or by lifting the grader blade and very few care to work during a rain. In other words at the very time that floating does the most good or is more necessary the tractors are performing their work satisfactorily.

The tractor outfits have more weight than the average horse-drawn maintenance grader and there is less tendency to leave a washboard effect on the gravel surface. Blades 8 ft. in length and from that up to 12 ft. in length were used.

The tractors took care of an average of a little over 13 miles each. All of the tractors did not cover their entire beat each day. The speed varied from 2 to 3 miles per hour, depending on the condition of the road and the character of the work to be done. For instance, the average speed of the various tractors during the month of July, taken from the report cards turned in to the office giving the hours employed and distance covered, was very close to 2 m.p.h., although it is possible to speed the tractors up to 5 or 6 m.p.h. During the majority of this time the roads were dry and hard, with little material to float with and a greater speed would have proven economical, due to increased vibration and wear on the machinery.

The average daily costs of operation have run between $10 and $12 per day.

CORRUGATIONS IN GRAVEL ROADS.—One of the problems of maintaining gravel roads is the removal of corrugations which form in the surface when the traffic reaches a certain density. Mr. A. H. Hinkle, Superintendent of Maintenance of the Indiana State Highway Department, states in *Roads and Streets* that their experience has fully determined that the corrugation is greatly reduced by the use of a very heavy drag or grader such that the surface is planed off smooth at frequent intervals. He states that they have found the following method effective in preventing corrugation. The frequent application of thin coats of new gravel will aid very materially in keeping down the corrugation.

The application of crushed gravel or crushed stone will reduce very greatly the tendency of gravel to corrugate. This no doubt is due, first, to the greater density of the mixture, than the ordinary gravel; second, to the cementing value of the dust, and, third, to the greater resistance the angular pieces offer to being shoved aside.

The dragging and smoothing of the surface with a heavy drag, plane or grader will greatly reduce the tendency of the road to corrugate. This latter means of keeping down the corrugations is extremely important under heavy traffic.

METHODS OF MAINTAINING BITUMINOUS PAVEMENTS.—Mr. B. C. Tiney, Maintenance Engineer, Michigan State Highway Department, gives the following in *Roads and Streets:*

Although strict adherence to the subject as stated would confine this discussion to bituminous pavements I am including water-bound macadam, as this is a type of surface upon which bituminous materials are used extensively in maintenance.

Between 1,500,000 and 2,000,000 gal. of tar and asphalt are used annually for the maintenance of roads in Michigan. Approximately 85 per cent of this amount is applied as a surface treatment on water-bound and bituminous macadam roads.

Application of Bituminous Materials.—Bituminous materials are quite generally applied by motor pressure distributors of various types. The pressure is usually afforded directly by a pump, operated by a power take-off from the transmission of the truck or in a few instances, by a separate power plant. A powerful truck motor is required if it has to operate the pump as well. The pump is so designed that it can be used for filling the distributor from tank cars as well as applying material to the road surface. A cut-out may be so arranged that the exhaust from the motor comes in contact with the pump, and by warming the material increases fluidity and ease of pumping.

It is important that distributors be equipped with heating arrangements. Even though the material is brought to the required temperature in the tank cars, a long haul or other delay will often necessitate reheating on the road. Heating equipment may consist of oil burners or steam coils. Steam is, in one type of distributor, generated by a small boiler on the rear of the truck, but it is more commonly supplied from an outside source, which is not always conveniently located. The advantage of a self-contained source of heat is obvious as it permits of heating during a long haul so that the material arrives on the road ready for application.

Spraying manifolds are so designed that any width of treatment from 2 to 16 ft. may be applied, but common practice confines the application to about 8 ft. or half the width of roadway at one time, as this enables traffic to avoid the freshly laid material.

Distributors should be equipped with thermometer, pressure gauge, and speedometer. The tank should be calibrated in order that the correct gallonage may be charged to each road. The rate of application is varied by setting valves and by the speed of the truck. A table showing the quantities applied per square yard for different valve settings and truck speeds should be posted in the cab for use of operator.

Cost of Treatment.—The plan of operating distributors by county forces has, in all cases, proven very satisfactory. The quality of work performed has been excellent, and a material saving in cost has been effected. An analysis of costs in one of these counties for a season is as follows: Twenty-four roads, aggregating 405,000 sq. yd. were treated with 125,000 gal. of tar, averaging a little less than 1-3 gal. per square yard. Tar cost 9.4 cts. per gallon f. o. b. county in tank cars. Slag cover costing $2.25 to $2.50 per ton f. o. b. cars in county, was distributed in piles by motor trucks. Labor was 35 cts. per hour.

The average cost per square yard was:

	Per Sq. Yd.
Slag, in piles along road	$0.016
Preparing surface and spreading slag	0.008
Tar f. o. b. railroad siding	0.031
Application of tar	0.005
Gasoline, oil and overhead	0.006
Total cost per sq. yd.	$0.066

A portion of this material was applied hot. The costs given include a rental charge on equipment used.

The contract price in this county then for a treatment of 1-3 gal. per square yard was $0.113. On this basis we have a saving of $0.047 per square yard on 408,000 sq. yd., or approximately $19,000. About $4,000 of this amount is due to a reduction in the price of tar, leaving a saving of $15,000 which is chargeable to the performance of work by use of county forces and equipment.

Similar results have been experienced by other counties operating their own distributors, and it is believed that this plan will come into more general use. The installation of permanent tanks for storage of bituminous materials would add to the efficiency of the system. Demurrage and tank-car rental, which amount to considerable sums if weather conditions are unfavorable, would be practically eliminated. The shipment of material is liable to be, at best, an erratic proposition. Storage facilities would tend to co-ordinate shipment with application of material, enabling the work of distribution to proceed more steadily.

It is often possible to install storage tanks at such elevation as to permit of unloading from tank cars by gravity. Tanks should be of sufficient size to hold one carload (approximately 10,000 gal.) of material, and should be equipped with steam coils or other arrangements for heating.

Patching Small Holes in Road Surfaces.—In addition to regular surface treatments at intervals of from one to three years, depending upon the amount of traffic, it is necessary that bituminous macadam surfaces be patrolled frequently and small holes patched soon after they appear. The importance of this feature of the work is usually under-rated, but it is one of the answers to successful maintenance. Shallow breaks in the surface crust may be swept clean, given a brush coat of bituminous surfacing material and covered with a layer of stone chips. A brush coat is preferable to a poured treatment as it avoids an excess of material, which is very undesirable. The practice of patching holes

greater than ½ to ¾ in. in depth by pouring partly full of a cold bituminous surfacing material and covering with an excess of chips, has been quite common and should be discouraged. It is obvious that such patches will remain unstable for some time and a larger proportion of them will be displayed by traffic. Patrol maintenance on shallow patches may be conveniently handled by storing bituminous surfacing material in barrels sunk in the ground at intervals along the road. These barrels are provided with covers and are readily filled by a hose from the distributor tank. Piles of stone chips are also stored at necessary intervals. A patrolman equipped with a wheelbarrow, bucket, broom and shovel is enabled to patrol a maintenance section efficiently.

Holes of an inch or more in depth may be conveniently repaired by the cold patch method, being tamped full of a cold mixture of aggregate with cut-back tar or asphalt, which depends for its setting-up qualities, upon the evaporation of volatile oils.

The stone for this mixture may range in size from ¼ to ¾ in., fractured shapes being preferable to rounded pebbles. The quality of the aggregate is a large factor in the success of any bituminous mixture, and it is often found to be economy to chip in a hard tough stone at additional cost, rather than use a cheaper local material of inferior quality.

The mixture should be made in the proportion of 16 or 18 gal. of bituminous material to a cubic yard of stone. A small amount of coarse sand may be added, but is not essential to good results. An excess of either sand or bituminous material will tend to make the patch unstable.

It is found that the patches offer more resistance to displacement by traffic if the mixture is allowed to cure for a few days before placing in the road, and also, in case of the deeper holes, if a larger stone is used in the bottom layer of the patch, being surfaced with the finer mixture. The hole to be patched should be swept clean and painted lightly with bituminous material before tamping in the mixture. A light sanding of the surface prevents adhesion to traffic while curing.

Mixing Stations.—Where considerable quantities of cold-patch are used, the mixing is most efficiently performed by means of a small concrete mixer. This may be housed in a building of sufficient size to provide space for mixing and storage of materials. The design of the building should be such that a motor truck may be driven into it and at least a part of the materials handled mechanically.

A number of such mixing stations placed at central locations for given maintenance sections, could be constructed on standard plans, so that one mixer could be readily moved by truck and made to do service for all stations. In this way a supply of mixture might be kept on hand and curing at each station.

A hundred miles of bituminous surfaced road, for example, might be divided into four 25-mile sections, each having a central mixing station so that the average haul of mixed material would be only 6 or 7 miles. This condition would, of course be ideal, the work being, in general, more scattered, but it is believed that in most cases a satisfactory arrangement could be worked out. Such a system has been in practice in Lucas County, Ohio, for the past 5 or 6 years and has proven very efficient. The mixing stations here are used also for storage of equipment and as headquarters for other kinds of maintenance work.

Bituminous Macadam for Patching.—Extensive replacements of bituminous surfaces are often made with bituminous macadam, by the penetration method. Two sections of a certain trunk-line of this state have, within the past four years furnished notable examples of road failures. They were quite widely separated but had many characteristics in common, the construction of both being a Topeka surface on a cement-concrete base. The failures were caused by a combination of heavy traffic, poorly-drained subgrade, and insufficient thickness of base. The maitnenance of these roads presented a difficult problem. Both were main arteries carrying an average daily traffic of 2,500 to 4,000 vehicles, many of which were heavily loaded trucks, and it was imperative that extensive replacements be made with as little inconvenience to traffic as possible.

This consideration led to the choice of bituminous macadam for replacement, as these patches could be placed under traffic almost as soon as they were finished. The general method of procedure was to remove sections of the broken pavement and the subgrade to a depth of at least 11 in. below finished grade, or deeper if necessary to obtain a firm foundation for the new work. It was often found necessary to go to a depth of 18 in. to 24 in. The lower portion of the patch was constructed of macadam in 4-in. layers, compacted by a roller, if the patch was large enough to permit a roller to work, otherwise being hand-tamped. In the case of some of the larger patches, the upper layer of this macadam base was water-bound, but in most instances it was werely dry-filled with screenings. The surface course of bituminous macadam was then placed to such height that it rolled down flush with the finished grade of the old pavement. None of these patches have ever failed under traffic, some having been in place for three years, being given surface treatment maintenance.

This work is rather expensive, costing from \$5 to \$7 per square yard, but the conditions were abnormal and any type of replacement would have been very costly. Had it been possible to have closed the roads to traffic, a saving of at least 25 per cent would have been effected. It is thought that these roads may, ultimately, be rebuilt with a heavy macadam base and a high-type surface, in which event many of the large patches will have a salvage value. In fact, 4½ miles of one section have been reconstructed using a 3-course water-bound macadam, 12 to 15 in. thick, which is at present carrying traffic on a surface treatment. The idea in this case is to let the macadam season under traffic for a time before placing a high-type surface.

Maintaining Asphaltic Surfaces.—The maintenance of asphaltic concrete or sheet asphalt surfaces in locations where an asphalt plant is not accessible is often carried on by the use of small portable plants wherein the asphalt and aggregate are heated in separate compartments and the mixing is done by hand. A gang of four men using one of these plants can mix and lay from 30 to 60 sq. yd. of surface daily. A roller is not required on these small patches as they may be compressed by hand tamping with hot irons.

In relieving ruts and depressions in an old asphaltic pavement by the addition of fresh mixture, the new material may be bonded to the old by first softening the latter with a surface heater. The heat is applied by oil burners and confined to the pavement by a hood. Care must be taken to avoid burning the old material, although no flame comes in contact with it.

Old material taken from an asphaltic pavement may sometimes be reheated and used again. This plan is used a great deal in the winter maintenance of asphaltic streets in the city of Cincinnati. The old pavement is broken into pieces about 2½ in. in size and placed in four-wheeled kettles of 100 gal. capacity. About 4 or 5 gal. of water are added, the kettle is covered and the mixture allowed to steam for about one-half hour.

SURFACE TREATMENT OF GRAVEL ROADS WITH ASPHALTIC OILS IN CADDO PARISH.—J. T. Bullen, Parish Engineer, Caddo Parish, Louisiana, gives the following in *Roads and Streets:*

In Caddo Parish, Louisiana, we have been building gravel and macadam roads since 1912. By gravel I mean a sand clay gravel composed of from 50 to 70 per cent water worn pebbles combined with 30 per cent to 50 per cent of clay and sand, with the sand predominating to some extent. The sand should have some coarse grains and the clay have good binding qualities. Our seasons are 9 months summer and 3 months of winter. Average winter temperature is about 45° and average summer temperature is 83°, though the temperature frequently goes down to 16° in winter and stays above 90° for days at a time in summer and frequently stays around 95° to 100°. We have little or no snow or ice and frost does not penetrate to any depth. One-fourth of our roads lie in the flat bottom lands of the Red River of the South and three-fourths lie in the hills with occasional grades up to 8 per cent and 10 per cent. Our annual rainfall is about 54 in. and sometimes 16 or 18 in. in a month. We have 47 miles of paved roads and approximately 15 miles of macadam and 120 miles of gravel roads.

Notwithstanding our 54 in. rainfall, we frequently have long dry spells lasting for many weeks and even months. Such dry spells are sometimes followed by torrential rains,—3 in., 4 in., or even 6 or 8 in. in 24 hours. In the dry spells the clay gravel ravels and gets exceedingly dusty and on steep grades a torrential rain will easily form gulleys in the surface.

The First Oiling Work in 1913.—Add to such difficulties a traffic increasing at the rate of 100 per cent annually and it becomes clear that an untreated gravel will not sustain the traffic for long, nor be an economical surfacing. We realized this in 1913 and, so far as I know, Caddo Parish was the first locality to try heavy asphaltic oil as a surface treatment for clay gravel roads. In August, 1913, the first oil was applied. All of the mileage to be treated had been completed from six months to a year and was pretty thoroughly consolidated and smoothed out. First the gravel was very thoroughly swept with a rotary steel broom which generally removed from ⅛ to ⅜ in. of fine pebbles, sand and clay and deposited it in windrows on the shoulders of the road. Hand brooms of a type used on city streets were also used to clean any part of surface not thoroughly cleaned by the rotary sweeper. Oil was then applied at the rate of ⅓ to ½ gal. per square yard at a temperature of 225° to 300° F. and was immediately covered with the sweepings previously swept from the surface. Our first oil contained about 85 per cent to 89 per cent bitumen and was obtained from California.

One-half of the road was treated at the time, the other being left open for traffic, and though 18 or 20 men followed closely behind the distributors, covering the oil with the sweepings, some vehicles would get on it and pull strips of oil from the surface before we could get it covered with the sweepings. The distributors' nozzles, one or more, would occasionally become clogged and cause skips, all of which had to be touched up a few weeks later, but in 30 to 60 days' time travel had ironed out the oil into an almost perfect surface, resembling an asphaltic concrete pavement.

The first oiling was done in August, and in September we had 16 in. of rain, which did not damage the surface in the least. It continued in good surface during the winter of 1913 and spring of 1914. At the end of 12 months, with the exception of a few breaks, it was still in good condition and an auto traveling 50 miles an hour would raise scarcely any dust. In about 15 months the broken places in the surfaces began to show to a considerable extent and at each break in the oil a chuck hole was forming. To make a long story short, in 18 months the general surface was very rough and not nearly so easy riding as the untreated gravel road.

The freight on the oil made it expensive and the cost of distribution by contract seemed higher than we could afford.

A few years later we were able to procure the same class of asphaltic oil from Baton Rouge, La., at a lower price and with much lower freight rates and we began the oiling of the roads in a systematic way.

Bear in mind when I say oiling that I do not mean the usual coating of light cold oils which are frequently used as dust layers or even those oils slightly heavier which require several coats to form a surface. It has been my belief from the inception of this work that to quickly get the asphaltic surface on the gravel with the least labor, was the true objective.

Kind of Oil Used.—Consequently from the first we have used heavy asphaltic oil such as the grade known in the market as Standard Binder A or Texaco Macadam Binder.

The consistency of this asphalt is such that it takes considerable heat to get it out of the tank cars, which is accomplished by connecting a steam line to the coils provided in such cars and this steam is applied for about 10 or 12 hours, or until the asphalt is hot enough to flow by gravity into our concrete storage tanks or be pumped into our distributors.

Our concrete oil reservoir has steam coils in the lower part into which we can turn live steam when it is desired to withdraw it to distributors.

The Personal Element in Oiling.—One thing I would like to stress at this point is in regard to the personal element entering into the work.

It takes an observant, conscientious and painstaking foreman to get the best results and a complete record of each tank distributed should be kept. In that record should be noted the comparative character of cover (fineness or coarseness), how many days of dry weather preceding the treatment, and every condition of weather, surface or oil which might have an effect on final results. With such a record the failures should gradually be eliminated.

It is quite easy to apply too much oil and without careful checking of surface covered, you will not always know from a foreman's report whether ⅓ or ½ gal. per square yard has actually been used.

Gravel or macadam roads with steep grades treated with heavy asphaltic oils are insured against longitudinal or transverse gullies which would be caused by heavy rains on untreated surfaces.

Important Details.—In a treatment apparently so simple the details are quite important.

The details necessary for success are: First a surfacing material bound so thoroughly together that when it is swept the gravel or stone remains in place, and only a small part of the binder can be swept out, leaving slight crevices for the oil to get its grip.

A gravel with binder too sandy is almost sure to fail, because you cannot sweep it clean without loosening the surface.

It is essential to get the surface well consolidated by traffic before applying oil, so that the gravel will not ravel under the oil.

Apply only sufficient oil to completely cover the surface; the first application generally requiring between ⅓ and ½ gal. per square yard.

Later applications generally require about ¼ gal. per square yard.

It would probably give better results if the oil could be left uncovered for from 12 to 24 hours. With us we have few roads over which to detour traffic, consequently we cover the oil immediately after distributing it. A gang of men follows the distributer casting back on the road the fine gravel, the sand and clay previously swept from its surface.

We have found these sweepings make an excellent cover, containing, as it does, particles from ¾ in. down to fine clay. In casting this material on the oil, it is well to cast it in lines parallel with center line and not transversely. The cover must be in quantity sufficient to prevent vehicles from picking up the oil.

After the first application there will be no sweepings, therefore cover will have to be hauled in for subsequent treatments. We sometimes ship in a coarse sand for this purpose and sometimes use a fine pea gravel or broken stone with dust left in. The stone is probably to be preferred, though we find a sand graded from fine to coarse serves excellently for the purpose.

I have even seen the oil covered with stiff red clay and, to my surprise, it ironed out in good shape. The clay is not desirable for several reasons, one of which is that it leaves no grit in the surface to reduce slipperiness.

As a matter of fact, we find that our oiled roads are not slippery; the cover composed of the sand and small pebbles or stones gives it a good, almost non-skid surface.

Repairing Breaks.—In repairing the breaks in the oil, we use standard cold patch or Texaco cold patch which costs about 16 ct. per gallon in barrels. This we mix with small stones and allow it to cure for a few days so the volatile oils may escape, and this material is spread cold and tamped in place after cleaning out loose material from holes and painting holes with cold patch, or some other thin asphaltic oil.

Don't begin using oil on your roads unless you can, and will, afford to apply a renewing coat of say ¼ gal. per square yard at intervals of 12 to 18 months and prepare to begin patrolling oiled roads as soon as oiled. The little breaks must be touched up with oil from hand pouring pots or with cold patch as soon as they appear.

I don't think there is any question of the economy of such a surfacing. We are compelled to use a soft marble for macadam roads—a material which under our traffic of 1,000 to 4,000 vehicles per day would wear into deep holes and ruts in two or three months unless protected by an oil mat.

With the oil surface, this same material does sustain the above mentioned traffic for years at a time, with practically no loss of material and no rutting. We have such macadam surface constructed over 5 years ago within 3½ miles of the Court House at Shreveport (a city of 75,000) and carrying heavy oil field traffic, and they have been maintained in good surface for less than $500.00 per mile annually and with no additional rock.

Several coats of oil have been applied and sufficient oil has now been applied to cause same waviness in surface.

A little later we will have to scarify the surface lightly, re-roll it and re-oil it.

The same statements apply to many miles of our clay gravel roads which are in excellent condition several years after first application of oil.

The Louisiana Highway Commission has been keeping a careful check of traffic on the state highways, and, in a recent issue of their monthly magazine, it is stated that the maintenance costs on untreated gravel roads amount to about $600 per mile annually and that notwithstanding this expense for maintenance, traffic is wearing away or winds and rains carrying away about 1 in. of gravel per year, estimated to cost $1,000 per mile per year, or a total cost of approximately $1,600 per mile per annum. With the oil surfacing, the $500 or less, per mile maintenance charge is the total annual cost, because the gravel cannot wear away, blow away or wash away.

Savings from Oiling.—Then consider for a moment the saving which oiling effects for the users of the road. Information from university tests and actual costs in several parts of this country indicate that the saving to automobile owners in gas, oil and tires effected by a paved surface in comparison with an ordinary gravel surface is at least 1½ ct. per mile and even 2 ct. per mile. I am convinced that, as compared with a loose gravel surface such as we have in Louisiana during our long dry spells, the saving effected by oil surfacing must be at least 2 ct. per mile.

As a matter of fact, one of our transfer companies runs about 50 busses a day over different routes out of the City of Shreveport. Some of these busses are confined to roads almost exclusively surfaced with oil, while others are kept on gravel roads unsurfaced, and although these unsurfaced gravel roads are machined almost daily, they have much loose gravel. In looking over the statement of maintenance costs on the equipment of this company which had been worked out in the cost per mile, I was interested in the fact developed by those costs, that the busses operating over the untreated gravel roads were costing about 2 ct. more than those operating over the paved and the oil surfaced roads. And the difference in cost to the Transfer Company on seven busses operated over the untreated road amounted to $6,000 more than for the same mileage in a year over the oil surfaced roads.

This, mind you, is but the loss of one company on seven busses. What must be the loss to the whole traffic?

Of course you must add to these savings by the use of oil, the very great saving to the people in the abatement of the dust nuisance; the increased pleasure in the use of the road; the decided factor of safety in the prevention of collisions caused by dust and the enhanced value of property along the road because of the abatement of the dust.

Cost of Oil Surfacing.—We keep careful cost accounts on all our work, and for 5 or 6 years we find that there is but little variance in the cost. It runs from 5 to 8 ct. per square yard for first treatment, or $500 to $800 per mile on an 18 ft. surface. These costs include $30 per day for use of oiler, also the cost of sweepers, labor, foremen, trucks and covering material. The cost varies depending on length of haul, length of the stretch to be oiled and some other variable factors.

We sometimes take the oil over 40 miles from town and apply it at not to exceed 8 ct. per square yard.

If we could continue this work over any regular period, using the equipment each day, we could reduce these costs considerably, but we only oil, or re-oil, a mile, or perhaps 2 or 3 miles in one job, and then move

perhaps to a point 50 or 60 miles away, where the next oiling is necessary. A typical cost sheet is as follows:

Ida-Missionary Road Oiled—Outfit No. 2

Station 00 to Station 244.....4.62 Miles
Roadway 12 ft. Wide.....Total 32,533 Sq. Yds.

Recapitulation Cost

Trucks and Drivers	$ 75.15
Oilers and Drivers	366.68
Sweeper and Drivers	201.10
Labor Cleaning Road and Cov.	328.49
Oil (13,700 Gal.)	1,438.50
Foreman	60.69
Total	$2,476.61
Total Sq. Yd. Oiled	32,533
Total Miles	4.62
Total Gal. Oil	13,700
Gal. Per Sq. Yd.	0.421
Cost Per Sq. Yd.	.0761
Cost Per Mile	$ 535.88

Note: Hauled from Shreveport—40 miles.

We have recently tried the experiment of curbing a macadam road and oiling it to see how long we can maintain it in good surface. We were led to try this because almost invariably the oil surface begins to get ragged at the edges and more repairs are called for there than on the balance of the surface. This has only been completed about one year so it is too early to say much about it except that it looks like it is there for a good while to come, and certainly after a few years it should make an excellent base for some higher asphaltic type of pavement.

I shall append some figures giving typical detail costs of this character of work.

Cost Data.—Section "I" Arkansas Line Road—24.2 mile post to 285 mile post 16 ft. wide. Oiled in 1922, at cost of $583 per mile or 6 4/10 ct. per square yard. Second application of oil Nov. 7 to 15, 1923, at cost of 4 ct. per square yard, using coarse and fine sand for cover. Maintenance on this section for the 9 months of 1925—$248 per mile.

Section "K" of Arkansas Line Road—8.4 miles; June 27, 1922. 14 ft. in width. Cost per mile $382; or per square yard 4 7/10 ct., using 0.334 gal. per square yard. This section maintained for 9 months of 1925 for $200 per mile.

Mooringsport Road, Section "N"—This was an old gravel road with gravel 4 in. to 6 in. in depth. In March, 1922, from 3 in. to 4 in. of stone was added and 0.38 gal. of oil per square yard applied and in July, 1922, a light coat was applied. The total cost of the first application was $714 which figures out at $593.20 per mile or 6 cts. per sq. yd. The detail costs were as follows:

3/6	1 Truck and Sweeper 1 day	$ 35.00
3/7	1 Truck and Sweeper 1 day	35.00
	2 Oilers and Helpers 1 day ea. (@ $30)	60.00
	1 Truck for men @ $8	8.00
	Labor 50 hrs. @ 22½ ct.	11.25
	Labor 100 hrs. @ 20 ct.	20.00
	Foreman 10 hrs. @ $8	8.00
3/8	2 Oilers 1 day each	60.00
	Truck for men	8.00
	Labor 50 hrs. @ 22½ ct.	11.25
	Labor 100 hrs. @ 20 ct.	20.00
	Foreman	8.00
	Plant Expense 2 days @ $15	30.00
	Hauling sweeping from roadside, Outfit No. 45, 2 days	75.00
	4400 Gal. Std. Binder "A" @ 8 ct.	352.00
	1¼ Miles	$741.00

1 mile $593.20; 1 sq. yd. 6 ct.; Gals. per sq. yd., .38.
Maintenance—9 mo. of 1925, $210.94.

Mooringsport Road—3,700 ft.—18 ft. wide. Station 288 plus 80 to 325 plus 80. First application Standard binder "A". 30 Yds. No. 3 Winndield Stone and 30 Yds. bank sand covering.

5/22	30 Yd. No. 3 rock $4.25 per yd. in place	$127.50
5/24	30 Yd. Bank Sand $1.25 yd. in place	37.50
5/25	1 Oiler 1 day	30.00
	1 Truck Sweeping and hauling men	15.00
	Labor hand-sweeping and covering	31.75
	Foreman	8.00
	Plant Expense	15.00
	2500 Gal. Std. Bind. "A" @ 8 ct.	200.00
	1 Sweeper 1 day	7.50
	For 0.7 Miles	$472.25
	For 1 Mile	674.64
	1 Sq. Yd.	.064
	Gal. per Sq. Yd.	.34
	Cost of Maintenance 1925 to date, 9 mo.	144.90

(Oiling)

Lucas-Forbing Road—Oiling, May 1925.
12-foot Roadway Oiled.
1st Application Standard Binder "A."

Recapitulation Cost

Trucks and Drivers	$ 221.00
Oiler and Driver	84.75
Sweeper and Driver	79.75
Plant Expense	6.25
Sand (129 Cu. Yds.)	236.07
Labor-Loading Sand	53.87
Labor-Covering Oil	166.68
Binder "A" (7000 Gal.)	610.33
Foreman	53.83
Total	$1,512.53

Station 00 to 136	13600 Lin. Ft. x 12 ft.
18133 Square Yards	2.576 Miles
Total Gallons Standard Binder "A"	7000
Gallons per square yard	0.386
Cost per square yard	$0.0834
Cost per mile	$587.13

WISCONSIN PRACTICE IN GRAVEL ROAD MAINTENANCE.—J. T. Donaghey, State Highway Engineer of Wisconsin, gives the following in *Roads and Streets:*

There are over 25,000 miles of gravel roads in Wisconsin; about 5,000 miles of which are what is termed full depth gravel, or from 8 to 12 in. The majority of this is found on the 10,000-mile state highway trunk system.

The balance is what is termed light surfacing and from 5 to 8 in. in depth. This latter in the majority of cases has been built by the local units of government.

Rules for Maintenance.—Our experience has taught us that gravel road maintenance must begin the moment the material is in place on the subgrade, and to maintain the surface adequately, the following rules must be followed:

First: Be sure the road goes into winter in the best of condition. Ditches and culverts must be free and open and the surface must be smooth and free from holes and depressions that will hold water. Add gravel where needed at this time.

Second: Go over the entire road (surface and ditches) with a 12 ft. blade grader just as soon as conditions will permit each spring. Move the top inch of gravel back and forth at least twice. This insures removing all holes and depressions permitting the patrolman to begin the season's work with no handicap.

Third: Add new material at all places where the original material has been pounded into the subgrade by traffic. Add new material to the entire surface as fast as the original is ground up and blown away. This will be about ½ in. per year for each 200 vehicles per day travel.

Fourth: Keep a light mulch of fine gravel covering the surface at all times. The patrolman must move this mulch of gravel entirely across the surface once for each 800 vehicles of travel. As traffic increases, the patrol section must be shortened accordingly and the maintenance equipment increased in weight correspondingly.

When to Start Maintenance.—We begin maintenance work early in the spring just after the frost has left the ground or as soon as the surface is thawed to a depth that will permit working a blade grader.

At this time the gravel surface is somewhat loosened from the frost action and it is possible to cut off the high places and move them to the low places with more ease and more lasting results than at any time during the season.

The ridge of gravel thrown outside the wheel tracks by traffic is moved in towards the center of the road with the blade grader and naturally fills the ruts, holes and low places.

All large stone projecting is removed from the surface before adding new material.

Handling Material.—If additional new material is needed, it must be made available along the roadside during the winter months and added at this time as it will bond much better and more easily than at any other time during the season.

Where new material is needed to fill the holes and low places, use gravel that has passed through a screen having round perforations not to exceed 1 in. in diameter and containing but a small amount of binder.

When the holes and low places have been filled, the entire surface is gone over thoroughly with a grader having the blade set nearly at right angles, until a uniform and even surface is obtained. The blade is then set at the proper angle to shape up the surface to the proper cross section, which should not permit more than a 3-in. crown for a 24-ft. surface. The blade grader or planer is used frequently to keep the ruts filled, assist in compacting the gravel, and smoothing up the whole surface.

Piles of fine gravel for use in maintenance are placed along the road at convenient points outside the ditch line where patrolmen can easily get the material neecssary to fill the small holes and defects that may appear from time to time.

The material is delivered to the road by motor truck or on sleighs during the winter months, provided the haul exceeds 1 mile.

If the patrolman has material available along the roadside he can fill the holes immediately in the spring or after a rain and the water standing in the low places will show him better than can be shown in any other way, the exact depth of new material necessary to bring the low places to the proper crown.

The best time to add new material is when the holes or low places are filled with water.

When to Use Grader or Planer.—The best results are obtained with the blade grader or planer early in the season, just when the frost is leaving the surface, or after a rainy period of several days, at which time the entire surface has become so thoroughly soaked and softened up that material moved from the high places will bond readily where it drops into the low places.

Motor trucks are used to good advantage for pulling the grader or planer. An ordinary 3-ton motor truck will pull a blade grader or heavy planer very satisfactorily. This requires an extra man to handle the grader, but the extra expense is offset by this type of equipment being suitable for delivering material to the road.

Motor graders do excellent surface maintenance work, but are not satisfactory for cleaning out ditches. We find a good team patrol will cover a 6-mile section, a motor grader 13 miles, and a motor truck 20 miles. The team patrol is generally the best and cheapest.

Do not be afraid to use the grader or planer during dry weather on a gravel surface. The material thrown out by traffic should be moved in to assist in filling the depressions caused by heavy traffic and dry weather. All of the material will not remain in the depressions, but enough of it will to warrant the work. We find on those gravel sections where the patrolman keeps moving the surplus fine material back and forth across the surface even though the weather is dry that he invariably has the best riding section.

Scarifying and Reshaping.—Hundreds of miles of uneven gravel roads built in the past have been converted into excellent roads for travel by scarifying and reshaping. A roller scarifier or an ordinary heavy grader scarifier pulled by a heavy tractor is used. It is generally advisable to scarify to the entire depth of the gravel or at least to the depth of the deepest holes. Harrow thoroughly with a heavy peg tooth harrow and shape up the surface with the blade grader. The blade should be set nearly at right angles in order to remove the waves and depressions. Remove loose stones from the surface and use the grader or planer daily until the surface is well compacted. Add fine gravel where needed to strengthen the weak places and fill all depressions.

Untreated gravel surfaces that carry an average traffic of 400 vehicles per day or more should be scarified and reshaped twice during the maintenance season. The first time as early in the season as work can be done and the second time about Sept. 1. We generally have rains about this season, which will assist in bonding the gravel that has been loosened up with the scarifier. The surface will be in much better condition to go through the fall and spring wet season than if the holes and washboarding are allowed to remain.

Surface Treatments.—When traffic reaches an average of 300 vehicles or more per day some form of surface treatment should be applied in order to protect the surface of the road from grinding up and blowing away. Up to this traffic there is probably no question but what the addition of the required amount of new material from time to time will keep the surface of the road in very good condition at a lower cost per mile per year than can be done by any form of surface treatment. However, we must consider the material lost annually, which is not less than 300 cu. yd. per mile for an average daily traffic of 300 vehicles, and the danger and nuisance existing from the prevalence of dust.

Use of Calcium Chloride.—On roads carrying not to exceed 400 vehicles per day quite satisfactory results can be obtained by the application of calcium chloride or similar dust layers. The surface must be shaped to the proper cross section and reasonably well compacted before application. It requires an application of from ¼ to 1¼ lb. of calcium chloride per sq. yd. for the first treatment. Generally a second application must be made about midsummer requiring from 50 to 75 per cent of the first application, making in all not to exceed 2 lb. per sq. yd. per season. Calcium chloride is applied by the use of an ordinary lime spreader and one outfit can apply 2 miles or more per day. Calcium chloride does two things: first, it lays the dust quite satisfactorily, and, second, it conserves the material on the road surface, not so much as bituminous surface treatments, but enough to be recognized as a considerable saving per mile per year.

There is no question but what this treatment is beneficial, especially upon those surfaces that are not bonded sufficiently to treat with light tar.

Use of Light Asphaltic Oils.—There are certaain gravel roads constructed of such material that the surface is always covered with a heavy mulch of fine material that does not stay bonded but for a short time after each rain. On such roads a light oil surface

treatment works out very satisfactorily and at a reasonable cost. The surface must be shaped up properly and the oil applied at the rate of about ½ gal. per square yard. After the oil has penetrated the fine mulch, it should be moved back and forth with a blade grader, the same as untreated gravel would be handled, and must be gone over often enough with the grader or planer to keep it from becoming solid or shiny, at any point. If there is evidence of it becoming hard and shiny, it is well to apply a small amount of fine material and move it back and forth over this portion of the surface which will prevent such condition. This treatment will conserve the material, prevent dust, and is generally a satisfactory surface for one season. Frequently, however, it is necessary to give a light second application about midsummer. In this even the cost will be increased to whatever extent is required by the second application. It will not require quite as much material per square yard the second year as the first. However, if no application is made the second year, the surface soon gets in its original condition or worse. In other words, there is no permanent or lasting value in a light oil treatment. The total cost per mile per year, including new gravel and not including patrol maintenance, will range from $400 to $500. This form of surface treatment is generally satisfactory up to a daily average of 800 vehicles.

Use of Light Tar.—Where traffic reaches an average of 800 or more vehicles per day, the loss is not less than 1½ in. of surface annually, or not less than 450 cu. yd. per mile. Very few localities have enough gravel available to construct and maintain their roads for a 10-year period unless such material is conserved to the maximum. A loss of 450 cu. yd. annually would in 5 years provide sufficient material for a mile of new road. No community can afford this loss.

We use no material in the top 5 in. of a gravel surface which exceeds a size that will pass a 1 in. round opening. The material is generally crushed and not separated but is all deposited in the same bin and loaded into trucks from a chute in the bottom of the bin. This insures a uniform gradation. The same specifications prevail on all resurfacing of old gravel roads. This costs somewhat more than pit run gravel or gravel crushed to a larger size, but it is worth much more than the difference in such cost, especially where the surface must be scarified frequently.

Preparation for First Surface Treatment.—The surface is thoroughly scarified to a width of 20 ft. or more, and to a depth of the deepest holes appearing in the surface, which is generally not more than 2 in. It is necessary to lap the scarifier one-half in order to get the surface completely scarified, as material of this kind becomes extremely solid under heavy traffic and a once-over with most scarifiers will not produce the desired results.

Immediately following the sacrifice, the surface is shaped with a 12-ft. blade grader to a uniform cross section. The material is sometimes loose and dusty on account of the fine content, and a sufficient amount of time is permitted to lapse for the surface to become well compacted. A good heavy rain will aid materially. The surface is now swept clean with a rotary broom. The sweeper is hauled by a motor truck and leaves quite a windrow of dust and loose gravel, so that a light grader is used to push the windrow out of the way of the sweeper for its second trip. The surface is swept twice, and gravel in the surface projects just a little above the rest of the surface, producing practically a mosaic surface. Should there be any dust pockets remaining, they must be cleaned out with hand brooms. Some gravel surfaces may not need scarifying and are shaped up very satisfactorily with a heavy blade grader. This work should be done early in the spring, just as soon as the frost leaves the surface of the road.

Application of Tar Priming Coat.—After the surface is swept clean, the tar is applied as follows:

Light tar may be applied cold, but better results will be obtained if it is heated to 100° F. The distributor should be thoroughly cleaned before beginning operations and then kept clean. There should be a double strainer on the distributor tank intake in order to exclude all cinders that may be in the tank car as it is almost impossible to secure a tank car of tar without containing some cinders. It is also very necessary to have several extra nozzles so that if one becomes clogged it can be replaced immediately, which will permit the distributor to operate evenly. Even distribution is very essential.

The priming coat is applied at the rate of 1/6 to ¼ gal. per square yard on new surface treatments, and no sand or covering is spread over it. Forty-eight hours or more are permitted to elapse after the priming coat has been applied, during which time traffic irons out the surface in a fairly uniform manner. If the covering must be spread by hand and conditions will permit, immediately following the application of the priming coat the covering for the second coat should be deposited along the shoulder of the road. Be sure that the windrow of loose dust and gravel left by the sweeping has been pushed clear out over the shoulder with a grader before the covering is deposited along the shoulder as the covering material should be located on the shoulder outside of the edge of the surface treated portion and not be permitted to mix with the loose material swept off the surface.

Placing Covering Material.—Pea gravel, fine stone chips or clean, coarse, sharp sand is the best material to use for covering, and for a 20-ft. surface it will require about 50 cu. yd. per mile to cover the surface properly. The covering should be deposited in piles of about ¼ cu. yd. each, and 25 ft. apart, and care should be taken that the inside edge of the pile be entirely clear of the outer edge of the surface treated portion, for, if a thin film of covering opposite the piles should be covered with the second application of tar, it would pit out at that point and produce very unsatisfactory results.

The reason for depositing the covering in advance of the application of the second coat is that a certain amount of covering must be applied immediately after the second coat of tar touches the surface, which prevents the tar from running and permits it to penetrate the surface, thereby forming a skin coat and not a mat. The covering if deposited along the shoulder is also available to add immediately in any amount desired to prevent picking up and to cure bleeding.

Application of Second Coat.—Should several days have elapsed before the second coat is applied and the surface have become slightly loosened or dirty, it should again be swept lightly to remove any loose material. The distributor is now set to spread about ⅓ gal. per square yard on a first surface treatment, and care must be taken to have the tar spread uniformly.

Where the covering is spread by hand a number of men (from 6 to 10) are stationed along the sand piles from 50 to 100 ft. apart. When the distributor is started along the road, the man at the first pile spreads a little less than one-quarter of the covering in his first pile on the width covered by the distributor opposite the pile, doing the same with the next pile and so on, working rapidly. The second man does likewise when the distributor reaches a point opposite his first pile.

and so on down the line of men. The first man, upon reaching the point where the second man started spreading, moves ahead of the line of men, beginning a new station the required distance from the last man in line. Handling the covering in this manner permits applying a small amount immediately after the tar touches the surface of the gravel, and prevents the tar from running off the road surface and assists it in penetrating the gravel, which is what is desired. To do this part of the work cheaply and rapidly, on a large mileage, there should be two or more distributors on each job, one being loaded while the other is distributing. There will naturally be a certain amount of time elapse between the loads, which permits the sand spreaders to go back and add sand where needed to keep the tar from running off the surface or to stop picking up. The distance of the job from the supply of tar will, of course, enter into the question. The other side of the road is handled in just the same manner, and the distributor should be so equipped that two strips over the road will cover adequately the width of surface desired.

Extreme care must be taken to avoid spreading too much covering on the second coat until it has had time to penetrate the surface. If too heavy a covering is spread, or if the spreaders are careless and dump full shovels in a place, the result will be that the excessive amount of covering will absorb or blot the tar and prevent it from penetrating the surface and will result in a mat rather than a skin coat. The spreaders should use square point shovels and learn to throw the covering from the shovel in a manner that will produce an even application.

If the weather is reasonably warm penetration will immediately take place and after two hours have elapsed there is very little danger if more covering than is necessary is applied, as the tar will then have penetrated sufficiently so that the excessive covering will not blot the tar. One or two extra men should be kept on each mile for at least a day or two following the second application to apply covering where the surface starts to pick up or bleed, and a small amount of material should be let in about every third mile for this purpose.

Mechanical spreaders may be used, but if used, not to exceed one-fourth of the total covering required should be spread immediately following the distributor, an additional 50 per cent in about two hours, and the balance as needed to cure picking up or bleeding.

The most practical and convenient mechanical device for spreading sand, pea gravel or stone chips that the writer has seen in operation is in Dane County, Wisconsin. It was designed by the county mechanic. It will spread evenly at the rate of 20 cu. yd. per mile of 20 ft. width or any desired thickness in excess of that. It is very simple, can be attached to any dump body truck, and is not expensive to construct or attach.

Patching the Surface.—The patching material is composed of from 15 to 17 gal. of light tar equivalent to Tarvia B, mixed thoroughly with 1 cu. yd. of coarse sharp sand. The material must be mixed thoroughly, either by hand or in a mixer, and if it stands several weeks prior to being used after mixing, all the better. The volatile oils evaporate and when thoroughly cured the mixture makes a better patch and will stay in place much better. Patching material mixed the previous year has been used with better results than when used fresh. No more than 17 gal. of tar per square yard of sand should be used even though it is slow in mixing.

Those in charge of maintenance must watch the surface very carefully, especially the first ten days after the surface treatment is applied. If a hole or abrasion appears in the surface the loose material should be swept out clean and the hole filled with patching material. If there are any places that appear loose and do not harden up under traffic, they should be dug out to a depth where solid material prevails, the hole filled and the material well tamped in and given an application of tar, and in a few days covered with a coat of patching material. The patch will soon iron out and become equal to the balance of the surface. The patrolman must be sure to fill every hole just as fast as it appears noticeable to the eye, even though it is not more than the size of a silver dollar.

Outstanding Points in Tar Application.—The outstanding points to insure satisfactory results are:

(1) Do not add more than 1 in. of new material during the season in which the treatment is given. In other words, if a gravel road is to be surface treated any additions in material required in the line of resurfacing should be applied the previous season and permitted to compact during the late fall, winter and spring. However, light applications of ½ to 1 in. can be made early in the spring and get good results the same season. This material should be placed before scarifying the surface.

(2) The surface must be well compacted and uniform.

(3) The surface must be swept clean.

(4) The priming coat must be applied immediately after sweeping.

(5) The tar must be uniformly spread.

(6) The covering must be spread evenly, and a little less than 50 per cent of the required amount spread immediately following the distributor, the balance being applied later as required.

(7) If possible to close the road to traffic for 24 hours after the second coat is applied.

(8) The surface treatment must be followed up promptly and carefully by the patrolman or maintenance gang and patching material must be added just as soon as the slightest hole is noticeable on the surface. A well prepared surface should not require more than 7 cu. yd. of patching material per mile per year.

(9) Unless plans are made to patch every hole the moment it appears, it is better not to attempt to maintain a gravel road with this type of treatment.

The first tar surface treatment of a gravel road 20 ft. wide will cost from $900 to $1,200 per mile. This includes necessary preparation of the surface, the follow-up maintenance and the entire patching cost for the season.

Preparing the Surface for Retreatment.—Where a road has been previously treated by this method, preparation for retreatment, is as follows:

Any portions of the surface that are in perfect condition showing no holes, ridges or wrinkles, may be retreated without scarifying or breaking up with a blade grader. Under these conditions 0.2 to 0.3 gal. per square yard should be sufficient.

Those portions that are slightly uneven should be gone over with a heavy blade grader early in the spring when the tar skin coat is inclined to be loosened up a trifle from frost action and weather conditions, pushing the skin coat out to the shoulder of the road with the grader and following this up with a light blade grader such as is used in patrol work moving the material pushed to the side of the road back and forth across the surface of the road every other day for a week or two. The best results are obtained when the temperature is from 60 to 79° F.

This breaks up the old tar crust and the grader operations smooth up the surface of the road to a point where it is practically a perfect cross section. When the surface has become smooth and well compacted by these operations it is swept clean and the covering material placed in piles along the edge. The tar is applied in the same manner as outlined above and generally no priming coat is required. Should the surface require a priming coat it should not be in excess of 1/6 gal, per square yard. The coat required for the second year's surface treatment is approximatelly 1/3 gal. The third year and thereafter a less amount is required unless additional width is treated.

The application of tar, spreading the covering, the follow-up patching, and everything connected with the work is done just the same as on a new surface treatment.

Mixing Method.—Where the gravel surface contains but little binder and the surface is not well bonded, very good results may be obtained by applying the tar without sweeping the surface. The surface is brought to the proper cross section with a blade grader and immediately following this an application of 1/3 gal. per square yard is spread over the full width of the road.

About two hours is permitted to elapse after applying the tar to allow its penetrating the loose surface. However, traffic can pass over the surface almost immediately following the distributor without splashing but little tar on the vehicle due to the fact that it immediately penetrates the loose gravel surface. Two 12-ft. blade graders are now used to move the top ¾ in. of surface over well beyond the center of the road. Immediately following the second grader the distributor applies 1/3 gal. of tar per square yard on the solid gravel. Immediately following this the graders push the loose material from the other side over to the opposite side of the road and the tar is spread on the other half of the solid gravel. The loose material is now moved back and forth across the road surface three or four times. The blade is set at about a 45 deg. angle in order that it will roll the material along the blade which assists materially in mixing the tar and gravel. When the loose material has been mixed until it is all coated with tar, it is then spread out with the blade grader to a uniform thickness over the surface. Traffic is permitted to use it immediately—in fact, traffic is never shut off on this type of treatment. A light grader or planer is used continuously until the surface is thoroughly ironed out and well compacted, which will take about two days where travel reaches a thousand vehicles or more daily. Where traffic is less than this amount it will take slightly longer to iron out and become well compacted.

After the surface is well ironed out a seal coat of about 1/6 gal. per square yard is applied, followed immediately with a very light covering of pea gravel. The planer is again put in operation and mows the surplus pea gravel from the high spots to any depressions in the surface, resulting in a very uniform and smooth surface within a week or less.

This method requires about 5/6 gal. per square yard, and, of course, necessarily costs more than the ordinary surface treatment heretofore described. However, it insures a penetration of approximately 1 in. and also insures the entire surface being well bonded with tar. We find this type requires much less patching and less attention than the ordinary surface treatment. We tried out a mile of this type in 1923 and it came through the 1924 season without a re-treatment. Therefore, at the end of the two seasons it was cheaper than the ordinary surface treatment.

We are very much sold on this latter type and are satisfied that more of our treatments will be along this line from year to year.

We surface treated 200 miles of gravel with light tar in 1924, and treated 400 miles in 1925. Dane County alone treated approximately 200 miles in 1925. After three years' experience in Dane County with tar surface treatments the county board appropriated $150,000 as a special fund for the surface treatment of their main gravel roads.

It may be interesting to know that Dane County is one of the few wealthy counties in Wisconsin that has not bonded for concrete roads. While I am satisfied that their main roads should be of some highway type of surface, nevertheless they are getting excellent results with the surface treated gravel and are satisfying the general public and especially the farming public. The maintenance cost is well under the interest on a high type surfacing and as long as it remains at that point it can be argued that there is no waste of public funds.

In Wisconsin we find it practically impossible to get appropriations sufficient to build all our main lines of travel with high type surfaces, and we do find that we can maintain our gravel surfaces in a very adequate manner with light tar surface treatments giving the public a safe and pleasant road to drive and conserving our local materials by so doing until such time as funds may be provided for a high type surface.

MAINTENANCE OF HIGHWAY RIGHT OF WAY. —O. S. Hess, Managing Engineer, Road Commissioners of Kent County, Michigan, gives the following in *Roads and Streets*:

For the purposes of this subject let us consider that maintenance of right of way covers all of the work incidental to the proper maintenance of Michigan highways, except the work of snow removal and other activities necessary to the adequate maintenance of the road surface or wearing course.

Let us then proceed to outline the various kinds of work which properly come within the scope of this subject, after which we may go into the details of just how this work is being done, using the methods followed in Kent County as a guide. The various subdivisions of maintenance referred to include the following:

Guard Rail Maintenance.
Shoulders and Washouts.
Care of Drainage Structure and Side Ditches.
Maintenance of Markers and Signs.
Cutting of Weeds and Brush.
Forestry and Landscape Work.

There are a number of other items of maintenance work which could be included in this list but as they are more or less special cases and not of general interest, we shall stick to the six subdivisions just referred to as far as this paper is concerned. A study of the past four years' maintenance costs of Kent County shows that these six subdivisions of work make up about 30 per cent of the total maintenance cost. Incidentally it is worthy of mention that the cost of a majority of this work is a fairly constant factor, not greatly affected by the type of road surface or the volume of traffic.

Guard Rail Maintenance.—The maintenance and proper care of guard rails consists mainly in rebuilding broken sections from time to time and in painting frequently enough so that they are plainly visible at night. Broken portions of guard rails should be rebuilt and painted as soon as possible after the damage has been done. In order to do this economically it is necessary to keep a supply of guard rail posts, lumber,

cable and fittings on hand at all times. It is usually advisable to buy the posts and lumber in carload lots. If the repair work is on roads which are maintained by truck patrols, the material can be taken out to the desired points by the scraper men. The men who do the repair work can then drive an ordinary passenger car from place to place as they make the necessary repairs, thus saving the cost of operating a separate truck for this work. In other cases a guard rail repair crew of about two men, equipped with a light truck, can handle this kind of work very nicely, and carry all of their materials with them.

The manner in which guard rail painting should be handled depends largely upon the quantity of guard rail to be painted. If the quantity is small, it is only necessary to send out a couple of men with a light car carrying their supplies with them and doing the painting by hand. For larger quantities of guard rail, a spray machine should be used. Proper equipment for this work would consist of a 1 or 1½ ton truck with platform body on which would be mounted a small engine and air compressor outfit of sufficient size to operate two lines of hose. The paint tank should hold about 5 gals., this being a convenient quantity of paint to mix at one time. The best outfit is one with the engine, compressor and paint tank all compactly mounted on a small 4-wheeled truck. This kind of an outfit can be quickly removed from the motor truck, thereby releasing the truck for other work when rainy weather or other conditions make it inadvisable to paint guard rails. The paint crew should consist of two men, one to drive the truck and paint the inside of the guard rails, the other to work on the outside of the guard rail continuously.

A crew and equipment like this can paint nearly a mile of wooden guard rails in a day at a total cost slightly over 1 cent per lineal foot, including paint. In order to do this it is necessary to buy a first class lead and oil paint, such as would comply with the present Michigan Specifications for guard rail paint.

As a rule guard rails along gravel or dirt roads which carry a fairly heavy traffic should be painted every year. On paved roads, or other types which are not dusty, it is usually sufficient to paint them once in two years.

Shoulders and Washouts.—The work involved in maintaining the shoulders of the road and taking care of washouts is in most cases a matter of hauling dirt or other material and placing it in V-shaped depressions which have been caused by the action of water. Some of our more heavily traveled paved roads, however, present greater difficulties. For instance, some of the old 16 ft. concrete roads which are now carrying 4,000 or more vehicles per day are handling quite a volume of traffic on the shoulders. It is sometimes necessary in cases like these to use large quantities of gravel on the shoulders and to install a regular patrol system of maintenance to keep it smooth. For the purposes of this paper, however, let us consider shoulder maintenance as being in the class first mentioned, assuming that the latter type of work should be charged to the surface or wearing course.

For reasons of safety and convenience it is very important that shoulders be maintained at all times in a condition fit to be traveled upon. To obtain this result, it is necessary that the maintenance organization be prepared to go out on short notice during and following storms with the proper men and equipment to take care of this work. At such emergency times men should be sent out ahead of the regular maintenance crews to put up lanterns, red flags, barricades, etc., to warn traffic of the dangerous places. Ordinarily, the crew or unit to do the work consists of a motor truck and two or three men. The number of units sent out depends entirely upon the volume of work to be done. These crews obtain dirt or other material as close to the washouts as convenient and dump it into the holes, smoothing it up with hand shovels so as to leave the shoulders and grade in good condition again. Sometimes the side ditches are eroded so badly that something must be done to prevent further washing. This can be taken care of in a number of ways; namely, by placing stone, rip-rap, cobble gutters, sod or brush. It has been the experience of the writer that brush, properly placed, is about the most economical and effective method in most cases. Washouts in the backslopes of cuts can usually be prepared against further erosion by cutting ditches along the tops of the slopes and parallel to the centerline of the highway which will lead surface water away from the points which have been giving trouble.

Washouts on the shoulders can be greatly reduced by keeping the shoulders a little low for some distance each side of the low points in grades, thus permitting the water to run off at many points instead of collecting at one place and tearing out a large hole. Sometimes it is advisable to follow an entirely different plan where we have deep valleys with steep grades leading into them from both ways, especially if the shoulders are built of sand or other unstable material. In these cases the shoulders should be kept a little high so as to lead all of the water to the low points, and at such points there should be constructed wooden or concrete chutes or possibly catchbasins to take the water away from the road without damage to the shoulders. These are only a few of the more common methods of handling this kind of work. Each heavy storm, however, presents many and varied new problems which give the maintenance superintendent a splendid opportunity to use his ingenuity.

Care of Drainage Structures and Side Ditches.—It is obvious to anyone that the proper care and maintenance of drainage structures, especially under heavily traveled roads, is of paramount importance. The highways of practically any county contain culverts of all types and sizes. It is necessary then that we have available culvert materials of many different kinds and men with the right equipment and knowledge to handle them. In the case of concrete culverts which are failing, for one reason or another, it is often possible to prolong or delay the failure many years by bolstering up the present structure in a rather inexpensive manner. The exact work to be done is usually different for each case, and must be determined by the man in charge. For this work, as well as for concrete culverts which must be replaced by new ones, we must have equipment for mixing and placing concrete in comparatively small quantities. This calls for a truck equipped with a dump body for hauling materials and a concrete mixer of about 1 sack capacity. The mixer and engine to run it should be mounted on wheels so that it can be easily loaded onto the motor truck, and quickly transported from one job to another. The crew generally consists of a foreman, truck driver, carpenter, and two or more laborers. A crew of this sort can build headwalls, repair old concrete culverts and built new culverts up to about 12 or 15 foot spans. It is the belief of the writer that replacement jobs much larger than these can be more economically handled by contract, after having received competitive bids. On all concrete work which is being handled by maintenance crews, the same rigid inspection of materials and workmanship should be furnished by the engineering department as is usually furnished on contract work of a similar nature.

For failures in culverts of sizes up to 36 in. and in some cases larger the replacement may be of encased

tile, reinforced concrete pipe, corrugated metal or cast iron. If only a portion of the culvert has to be replaced, it is generally best to replace with the same material as the balance of the culvert. If the whole culvert has failed it is usually better to replace with something besides encased tile, as this type does not lend itself to maintenance work as well as one of the other types which can be placed without the use of concrete mixed on the job. It is also recommended that all driveway culverts be constructed without concrete headwalls. Field stone, laid up dry, around the ends is much less expensive, equally as satisfactory and better looking. Without concrete headwalls these culverts can be moved, lengthened or repaired without any loss of salvaged material.

In all of this culvert repair or replacement work it is important that the work be done with the least possible interruption to traffic. The circular culverts can usually be placed under a half of the road at a time leaving the other half for traffic. The concrete culvert jobs, however, present a more difficult problem. Generally it is necessary to contruct a temporary bridge or by-pass to carry traffic. The character of the detour constructed or the amount of money spent on it, is largely dependent upon the volume of traffic which the road carries. It goes without saying that in all cases it is imperative that the proper attention be given to the correct use of signs, lights, barricades, etc., to warn and direct traffic.

No matter how well the drainage structures are maintained they cannot furnish satisfactory drainage service without the proper attention to inlets, outlets, and side ditches so as to allow the free flow of water. As soon as possible after the snow has left in the spring, men should be sent out on all of the roads with definite instructions as to where and what to do to properly take care of this phase of the work. About all the men need is transportation facilities, shovels to work with and proper instructions. This same plan should be followed out again in the fall just before freezing weather. Sufficient attention to this part of the work will save many times its cost later on in other branches of the maintenance problem.

Maintenance of Markers and Signs.—During the past few years a fairly complete system of markers and signs has been installed on the state trunk line system of Michigan. Many of the counties have followed suit and now have a complete signing system on their county roads. Without adequate maintenance, however, such a signing system becomes almost worthless in two or three years. As the plan of caring for these signs must necessarily vary a great deal under different conditions I will proceed to outline the methods followed in Kent County and leave you to draw your own conclusions as to how it should be done elsewhere.

To begin with, the maintenance superintendent is assisted by four district superintendents. Each district superintendent is provided with a car and required to look after all maintenance work in his district, which, in each case, comprises about one-fourth of the county and includes 110 to 115 miles of county and state trunk line roads. He covers all of the roads in his district nearly every day, and at least two or three times a week he has occasion to visit the main plant in Grand Rapids.

The signs themselves are just naturally divided into two classes. We have the danger and warning signs, which are made of cast iron, and the distance and direction signs, which are stamped metal plates fastened with brass screws to a board back. Both classes of signs are fastened to cedar posts. The cast iron signs are rather expensive and it is therefore necessary to repaint them every year or two in order to keep them looking good. The plates for the other class of signs are comparatively inexpensive, however, and it is found to be more economical to buy new plates than to repaint the old ones. This condition has resulted in the county maintaining a small stock of both classes of signs on hand at all times.

As the district superintendent goes about his work he makes a note of any signs which are in need of replacement or repainting. In a day or two, when he is at the main plant in Grand Rapids, he procures from the stockroom the particular signs he wants. The plates which he receives are new ones and the cast iron signs are probably repainted ones. He carries these signs along in his car, and whenever he comes to one of the poor signs out on the road, the old sign is simply replaced by a new or repainted one, and the old sign taken along back. The old plates are thrown away and the old cast iron signs are taken back to the stockroom on the next trip in. Whenever a sufficient number of the danger and warning signs have accumulated at the stockroom, a sign painter is set to work repainting them and then they are again placed back in stock to wait for another trip out. This plan of handling the sign job has worked out quite successfully in Kent County and undoubtedly has some distinct advantages for a county organization. First, there is no lapse of time when a post is without a complete sign. Second, the work of replacing and transporting the signs does not require special trips by anyone, and is therefore economical. Third, the repainting of old signs is accomplished under more favorable conditions with more speed and better quality of work. Fourth, the weather is not a factor to be reckoned with, as is the case where signs are painted out on the road.

Although this plan of handling sign work is apparently very economical, economy is not its greatest asset. The chief advantage lies in the fact that the signing system does not have to wait for a general overhauling but is taken care of promptly and continuously, maintaining a complete and good looking system of markers and signs at all times.

Cutting of Weeds and Brush.—Only a few years ago it was the exception rather than the rule to find a road with clean looking shoulders and the roadside free from noxious weeds and brush. Today we find a different landscape. The county which does not take care of its roadsides is considered to be negligent in its duties and a back number in highway maintenance work. In order to obtain the maximum use and safety of the highway it is absolutely essential that the shoulders be mowed frequently. To prevent the spread of noxious weeds and to keep the highway looking right, it is necessary that the right-of-way outside of the shoulders be taken care of.

The shoulders should be mowed at least three times during the season. A good time to start this work in this part of Michigan is about the last week in June. All of this shoulder mowing, the first time over, should be completed in about two weeks, and the organization and equipment should be worked out accordingly. About a month later, the shoulders should be gone over again. The third and last mowing should be done about the last of August or the first of September. These dates are of course only approximate, as they would naturally vary with seasonal variations. The number of mowings are about right, however, for most roads in this part of the state. This work has quite generally been handled with teams and ordinary mowing machines. In a few places Fordson tractors with mower attachments have been used. Both methods are satisfactory.

The right-of-way between the shoulders and the fences is usually of such a nature that mowing machines cannot be used, and consequently the mowing

must be done by hand. There is no great haste about this work, and it is ordinarily satisfactory to start about the first of July and finish about the last of August. One mowing is sufficient, and it is not necessary to cut the grass. As a matter of fact, it is probably better to cut only the weeds, leaving the grass to go to seed. If this method is followed a few years will usually see the roadsides well sodded over with practically all the weeds crowded out. Incidentally, this plan of mowing will probably cost less than half as much of the cost of mowing the roadsides clean, grass and all.

There is not much choice as to the manner of handling this work. The usual and probably the best plan is to place a sufficient number of men out on the roads with scythes to complete the job in the time required. Men can ordinarily be obtained at laborer's wages to do this work and furnish their own transportation.

Forestry and Landscape Work.—A phase of our highway maintenance work which has not received the attention it deserves is that pertaining to the beautification of our roadsides. In this state, which we boastfully call the "Playground of a Nation," we are year after year passing up one of our greatest opportunities. And that is the opportunity to make our roads attractive to the outsiders, as well as ourselves, by properly caring for what nature has already placed on them in the way of beautiful trees and shrubs, and by planting more in the barren stretches. The satisfaction which we, ourselves, can get from our own beautiful and well kept highways should be sufficient cause for action along this line, especially when we consider the low cost of the work, but when we find, as we already have found, that in this state it will pay out in dollars and cents, there should be no hesitancy in going ahead on a conservative and sound policy of this so-called beautification work. It is important that we keep our roadsides, as well as the traveled portions of the roads, attractive in appearance as it is the beauty of our state which attracts visitors and tourists.

Only a few of the counties in the state have gone into this sort of work to any great extent. Kent County has been one of the pioneers, having employed a forester and carried on roadside beautification work since the summer of 1921. At the beginning of the work it was decided that the first and most important thing to do was to properly care for the existing trees and shrubs before going into any extended tree planting program. The years which have gone by have shown the wisdom of this plan. The roads of Kent County can now speak for themselves as to the results accomplished. In starting out on a tree-planting program, it must be remembered that no results can be expected from the standpoint of the looks of the highway in less than about 10 years time. On the other hand the proper trimming and care of existing trees and shrubs give immediate results. Of course, if funds are available for both kinds of work so much the better, but as a rule this is not the case at the beginning of the work. In the construction of new roads it has been necessary to remove but a comparatively few trees or shrubs of any ornamental value. Only such trees that interfere with the actual construction work or with traffic are removed. The trees or shrubs which add any beauty to the road or surrounding landscape have been saved where possible and in some places changes have been made in the alignment of the road to avoid the destruction of groups of trees. The policy of the Kent County Road Commission has been to keep all roads open to traffic throughout the year, and it has, therefore, been necessary to cut shrubs or groups of shrubs which cause drifting of snow upon the highway. While this has been found necessary in some instances, it has been found that in numerous other places the shrubs or groups of shrubs actually prevent snow from drifting by acting as a windbreak. In the case of newly constructed roads they are all thoroughly gone over by the forester and his trimming crews immediately after the road has been accepted from the contractor.

Kent County is unusually fortunate in having a great number of large and beautiful trees along practically all of its highways. These trees, many of which were planted by the old settlers, were very often neglected after planting and as a result when the work of preserving these trees and shrubs was started they were badly in need of care. At the present time the entire milage of state trunk lines and county roads on the Kent County Road system has been trimmed at least once and about 75 per cent of the mileage has been gone over the second time with the result that all of the highways so taken care of now present a very marked improvement in appearance. The improvement, however, is much more noticeable as time goes on than it is just after the first trimming has been done as the trees and shrubs, after trimming, often take on new life and present a more thrifty and healthy appearance.

The trimming work which has been done has consisted in the cutting out of dead, diseased, and superfluous branches, removing dead trees and shrubs, cutting off low hanging branches which obstruct traffic or corner views, and properly pruning and thinning all existing small trees and shrubs found on the right-of-way. All road intersections and corners have been cleaned out and cleared of all obstructions, giving the motorist sufficient view to prevent accidents. It is interesting to note that during the past year in Kent County no accidents have been reported due to obstructions at road intersections, corners and railway crossings. This situation has never existed previous to 1925 and as there has not been a general decrease in the number of accidents we can safely draw the conclusion that the work of cleaning out corners, etc., is directly responsible for the elimination of accidents at the points referred to.

In the development and preservation of our roadsides it has been necessary to ask the co-operation of pole using companies. The manner in which they have co-operated with us during the past four years has been very satisfactory. They have spent large sums of money in re-building and re-locating pole lines at our request so that at the present time their interests conflict with ours in very few instances. On all roads which have 100 ft. right-of-ways there is room for trees and shrubs as well as for pole lines. In locating pole lines on right-of-ways of 66 ft. there is no hard and fast rule to follow as this width of roadway is too narrow for use of pole lines without some interference of trees. The lines must, therefore, be located where they will interfere the least with the trees and at the same time be safe for traffic.

Due to the fact that it has been deemed more important to maintain the trees and shrubs we already have, not much planting has been done as yet although several small stretches of roadsides have been planted. In planting a roadside it is well to keep in mind to plant the proper species of trees. This can be best determined by observing what species of trees thrive best in the direct vicinity in which the planting is to be done. For handling this trimming work our forester has been furnished with a 1½-ton truck and the necessary tools which he needs in his work. While this truck is light enough to get to and from the work quickly it is also heavy enough to transport all the tools and the required number of men. A crew of 6 to 8 men with the equipment just referred to works steadily on the trimming of trees and shrubs from spring to late fall. The work of cleaning out corners and intersections is usually

handled by one or two men working separately and traveling from one place to another in their own cars.

Since June, 1921, Kent County has spent for all purposes in connection with forestry and landscape work along the highways over $27,000. This cost has trimmed 450 miles of roads once and about 300 miles the second time. It also covers the cost of cleaning out corners and intersections and the establishment of a number of wells in miniature parks at a number of points along the highways. Some of these little parks, which were established on corners where excess right-of way had been purchased, are now very good to look at and help to relieve the sameness and monotony of many of our highways. The cost of trimming this 450-mile road system the first time over averages approximately $40 per mile. The re-trimming work costs about $5 per mile. It has been planned to go over the entire county road system from now on every year and do the necessary trimming and other forestry work which shows up from year to year. It is estimated that this work will cost $5 per mile or less per year.

PATCHING PAVEMENT WITH BITUMINOUS CONCRETE.—H. O. Offutt, District Engineer, Indiana State Highway Department, gives the following in *Roads and Streets*, regarding experiences in Indiana with bituminous concrete patches:

Smoothing the surface of a pavement or macadam with bituminous concrete patches is a very particular job. It is tedious and slow and unless the gang is well organized, lost motion will develop in many places. We know we are far from perfect in doing this work, but we feel that we are doing fairly well and hope our experiences will assist others in doing this work.

How to Obtain a Smooth Surface.—A rough surface is caused by irregularities, some spots being too high and others too low. The low ones can be filled, but the high ones cause more trouble. These high places can be removed by bush-hammering, but we believe the bush-hammering injures the pavement and shortens its life, so whenever possible we try to build approaches to these high spots which will not cause the car to bounce. Therefore, in smoothing the surface of a pavement we try to fill all the depressions, which cause the car to bounce with a material which will soon harden and become as a part of the pavement.

The use of bituminous concrete in making these patches we find gives excellent results. This kind of concrete is made by mixing an aggregate with a bituminous binder. This mixture when first made is soft and pliable and can easily be spread into the depressions. The volatile matter in the bituminous material soon evaporates and with traffic compressing and compacting the mixture, it soon hardens and a patch is made which wears as good as the original surface.

These mixes are many and varied. In some the materials are mixed hot and in others they are mixed cold. The aggregate is also varied, different kinds of stone and gravel being used and various gradings of the aggregate called for, the bituminous binder being either a tar or an asphalt in some form. In doing work of this nature, we have found we get good results by confining ourselves to the use of a bituminous concrete made with a stone aggregate and a tar binder, and mixing both at normal temperature. We have used other variations and have obtained good results, but in this discussion we will touch only on the kind of mix.

Filling Depressions.—The work, while all done at the same time and by the same organization, is actually divided into two processes.

All depressions which require filling, and which are not over ½ in. in depth, are taken care of by a process which we call paint patching. In this class of work, the depressions after they are marked out, are painted with a hot tar and covered with stone screenings or pea gravel.

The depressions which are over ½ in. in depth, we fill with the bituminous concrete and cover with a seal coat. The depressions when they are not over 2 in. in depth are painted with hot tar, as in the first case, before the bituminous concrete is applied.

Survey of the Work.—After deciding to smooth a rough surface, the first thing to do is to determine, as near as possible, the amount of work to be done. The organization can then be planned and the materials and equipment assembled ready to begin work.

Driving and walking over the contemplated work and judging the roughness of the surface will give us some idea of what is to be done. By counting, checking, straight edging, etc., we can get an approximate idea of the number of bumps per mile. We can then prepare an approximate estimate of cost and a bill of material.

Estimating Work Required.—The conclusions we will give you under this subject are only rough approximations. They are stated for the purpose of giving the superintendent some data to go by in ordering his materials and are not to be used as a specification for doing this work.

From studies made of our work during the past season, we have arrived at the following :

A—The average patch will range in size from 3 sq. yds. to 5 sq. yds. Judgment in the field will have to decide which figure will best suit your piece of work.

B—1 sq. yd. of patch requires about

0.5 gal. tar for painting the depressions
0.25 gal. tar for mixing the bituminous concrete.
0.25 gal. tar for seal coat.
0.33 cu. ft. of stone aggregate.
0.33 cu. ft. of screenings.

We believe that a road surface which is considered rough will have about 200 patches per mile; one which is very bad will average as high as 700 per mile. Figuring as estimate for repairing one mile of surface having about 200 patches per mile, and figuring 3 sq. yds. as average size patch, we would have the following:

Patches per mile 200	
Square yards of patch 600	
Materials—	
Tar for painting patch	300 gal.
Tar for bituminous concrete	150 gal.
Tar for seal coat	150 gal.
Total tar	600 gal.
Stone aggregate for bituminous concrete	7½ cu. yd.
Stone screenings	7½ cu. yd.
Total stone	15 cu. yd.
Cost of materials—	
600 gal. tar	$100.00
15 cu. yd. aggregate or screenings	45.00
Miscellaneous (hauling, crayons, etc.) 10%	15.00
	$160.00
Labor, 90%	145.00
	$305.00

These figures were the average amounts of material used and turned in on the completion report for a ten mile project in Warrick County, the surface conditions being about the same as stipulated above.

Organization.—When you have a fair sized job ahead of you, it is best to so organize your gang that one man will keep busy at one or two operations continually. He can soon be taught to do these few operations quickly and easily and then he can go ahead without being watched. A gang organized on this basis should consist of the following:

The foreman of the gang has many duties. First of all he exercises a watchful attitude over the whole gang and keeps things in general going smoothly. He should watch the work of the marker and finisher very closely, as their work must be done right. He checks over the finished work carefully and corrects any bumps which have been left. He usually applies the screenings in making the paint patches and assists the tar man in applying tar when necessary, and moves the equipment along the road as progress is made. A good way for the foreman to keep check on results of his work is to look back over the work occasionally and notice whether cars going at a good rate of speed do any bouncing. Usually if a bump has been missed or a patch made too high, it can be detected in this way, or if he has a car available he can try it out himself, checking the uneven spots as he drives over the finished work.

The gang consists of the following:

Two men to mix the tar and stone (making the bituminous concrete) and deliver it to the patching gang.

One man to measure and mark out the patches. When he gets ahead with marking, he should drop back and assist the wheelbarrow man by loading the empty wheelbarrow for him.

One man to sweep surface where the patch is to be made. This man has some spare time which is taken up by helping the wheelbarrow man, usually by loading his empty wheelbarrow.

One man to tend tar kettle, handle and pour hot tar on depression.

One man to wheel and shovel the bituminous concrete onto the patch.

One man to spread the bituminous concrete and finish off the patch.

Equipment.—The equipment necessary for a gang of this size should consist of the following:

One truck—2-ton capacity.
One truck—1-ton capacity.
One trailer—2-ton capacity.
One concrete mixer, 7 cu. ft. capacity.
Three wheelbarrows.
One tar heater, 200 gal. capacity.
One wire push broom.
One fibre push broom.
One stable broom.
One 14-ft. straight edge.
One 16-ft. straight edge.
Two 2-gal. tar pouring cans.
Four 10-qt. pails.
100 ft. common chalk line.
One box boiler makers crayon.
Two finishing shovels.
Various square point and round point and gravel scoops.

Description of Equipment.—The 2-ton truck is used to pull the trailer and tar kettle, and also to hold the screenings.

The 1-ton truck is used to haul the bituminous concrete from mixing plant to the patching gang and also to haul the men to and from work.

The concrete mixer must be a tilting drum type to give satisfactory results.

The straight edges are 2 in. x 6 in., one 14 ft. long and one 16 ft. long. They are best made from cypress, as they should be as light as possible. They are made 2 in. thick to prevent warping. The 14 ft. straight edge is for the finisher and the 16 ft. one is for the marker.

The tar pouring cans are made from galvanized sprinkling cans with the spout cut off about ½ in. from the body of the can, and the remaining part of the spout squeezed almost together, leaving an opening of about ¼ in. x 5 in. This kind of an opening tends to spread the tar very uniformly, and saves time spreading the tar.

The finishing shovel is a long handled shovel, and should be as light as possible, and have a square point 12 in. wide. A wider point is hard to handle and one more narrow slows down the speed of the finishing. This can be made by putting a long shovel handle in an old gravel scoop. Usually an old scoop will be worn and thin, which makes a light serviceable tool. The gravel scoop point can be heated and the point flattened out so that it will be level all along the bottom of the point.

The crayons used will run about 36 to the mile, so, often it will not be necessary to buy a whole box.

Materials.—The tars used are TP2, TM and TCM. The TP2 is used to paint the depressions, to hold the screenings or bituminous concrete in place, also to be used in making the seal coat, unless there are a large number of square yds. to coat, when TM should be used. The TCM is used to mix with the aggregate to make the bituminous concrete.

The aggregate is usually of stone, although in gravel country pea gravel can be used in place of screenings. The sizes of aggregate used are as follows:

No. 6 screenings	½ in. to ¼ in.
No. 46	¾ in. to ¼ in.
No. 3b	1 in. to ¼ in.
No. 34	1½ in. to ¼ in.

We used as large size aggregate as possible in the bituminous concrete, which was to be applied in the depression. To do this, we made three different sizes of bituminous concrete. One size was made out of the No. 46 stone, one out of the No. 3b stone, and one size out of the No. 34 stone. In a depression of ½ in. to ¾ in. we applied the bituminous concrete or mix made of the No. 46 stone. In one having a depth of ¾ in. to ¼ in. we applied a mix made of the No. 3b stone. In one having a depth of 1¼ in. to 2 in. we applied a mix made of the No. 34 stone.

In almost any depression a slightly larger stone size should be used than the measurements will call for. It is always advisable to use as near the proper sized aggregate to bring the surface up to normal as can be used. This, we think, would apply to any patch with a depth up to 4 to 5 in., using for a 4 in. depression a 3 or 4 in. stone if available.

Mixing Operation.—The mixing plant should be located near the road, and moved when necessary, so as to never be more than 2½ miles from the patching gang. At this plant should be kept the aggregates, the tars and the equipment for mixing. The equipment will include the light truck, the mixer, two 10 qt. pails, shovels and scoops.

Careful attention should be given to the arrangement and layout of the plant so that all lost motion be eliminated. One good way is to place each size of aggregate in a pile, arranging the piles in a row, so that the mixer can be moved along the row and the aggregate loaded direct from the pile into the loading hopper. The correct amount of aggregate is measured and placed in the hopper and leveled. A line is then painted around the inside, at the height of the leveled aggregate, which would show the loader how much stone to put into the hopper for each batch. The barrels of tar TCM should be handy to the mixer, but not in the way. They should be elevated above the ground high enough to place a pail under the bung. A standard molasses gate screwed into the bung saves time in handling the tar and also stops considerable waste.

The mixing is done by two men. One man loads the receiving hopper and brings the tar for the next batch. The other man dumps the mix onto a dumping platform, from which he then loads it into the light truck, ready to be hauled to the patching gang.

The batch must be allowed to mix thoroughly until each particle of the aggregate is completely coated with tar. The stone must be thoroughly dry and free from dust and dirt. Tar and damp stone will not mix, and bituminous concrete made with damp stone and put on the surface will disintegrate and ravel under traffic. A two or three days' supply of stone is kept covered during the night and during rainy weather. In this way enough stone can be kept dry to keep the work going until the wet stone dries out. When a gang is laid up from work a couple of days, it disrupts the organization and it will take about half a day to get them lined out again when they do get started.

For 1 cu. yd. of aggregate, we use from 14 to 16 gals. of tar TCM, this amount being regulated by the size and cleanness of the stone. The temperature also has some bearing upon the amount used.

The two men mix and deliver to the patching gang about 1 cu. yd. of mix per hour. One batch will make about 5 cu. ft. of mix, the average time of mixing a batch being about 4 minutes, the balance of the hour being taken up in loading and delivering the mix to the patching gang. The average daily consumption of mix for a gang of this size will run from 7 to 8 cu. yds. so by the time the mixers produce this much mix, clean up and get ready for the next day's run, their time is pretty well taken up.

Patching Operations.—On the way to work in the morning, the patching gang stops at the mixing plant and loads up with materials. The truck is filled with 2 cu. yds. of screenings, on top of which, 2 or 3 bbls. of tar TP2 is placed. The trailer is filled, with various amounts of the three sizes of bituminous concrete, depending upon the character of the surface to be patched that day.

Arrangements should be made by the foreman that one of the gang, the first thing in the mornings, goes to the tar kettle and starts a fire, so that the tar is ready for pouring when the gang arrives on the job.

Outlining the Depression.—This is done with a straight edge or line. It is rather a tedious task and should be done by someone who is a reliable workman. The depression is outlined with crayon, marking where the straight edge and surface begin to separate. The straight edge is laid parallel with the center line of the pavement about 1 ft. from one edge. Marks are drawn on the pavement showing the outside limits of the depression, the straight edge is then moved over about 18 in. or 2 ft. and the marking continued until the other side is reached or the patch runs out. The marker should also write the depth of the depression just outside the outline so the men applying the bituminous concrete will know what size to use.

The marker outlines all depressions of ¼ in. depth that or over 3 or 4 ft. in length. Depressions of this depth, but over 4 ft. long will not cause a car to bounce. Occasionally the marker will find a depression that the 16 ft. straight edge fails to cover. The foreman then assists him with a line, the line being held to the surface on each side of the depression, which is then outlined the same as when using a straight edge. On a place of this kind, the foreman must use his good judgment as the depression might be entirely too long to repair. If the depression is not over 1¼ in. deep, its length over 18 ft., and its approaches to the normal surface are gradual, it would not need filling.

Patching.—Following the marker, the sweeper thoroughly cleans the surface, using a wire push broom and a stable broom. The wire push broom is used to scratch up any foreign matter which may be stuck to the surface and the stable broom is used to sweep the dust off.

As soon as the depression is thoroughly cleaned, the tar pourer applies a coat of hot tar TP2 to its surface, except when the depth of the depression is over 2 in. deep. Where the depression is shallow (¼ in. or under) the application is made slightly heavier, as it is to be a part of the paint patch. The tar pourer should use two 2 gal. tar pouring cans instead of one 4 gal. can, as the two gal. cans are much easier to handle. After the tar is applied to the depression, he spreads it, using a fibre push broom. We first used a squeegee, but found that the fibre broom made a more uniform spread, the squeegee having a tendency to ridge the tar at its ends, which makes a ridge in the paint patch. This trouble, however, is more noticeable in repairing a rigid pavement than it is on a bituminous macadam.

Applying the Screenings (Paint Patch).—On the outside edge of the depression where the depth is under ¼ in., or over the whole depression if it does not exceed ½ in., the dry No. 6 screenings are applied. Judgment must be used in applying the tar and screenings in making these paint patches or feather edging the bituminous concrete patches, more tar and screening making a thicker mat, being applied at the deeper spots so that when finished the patch on its surface will be smooth and level with the surrounding surface. The foreman himself should apply these screenings because it is particular work.

Too many times we find the men applying too thick a coat of screenings. While this extra thickness of screenings is not harmful to the patch as the tar will only absorb so much, it is a waste of material. The dry screenings and hot tar are used for this purpose in preference to a bituminous mix, using this size aggregate because it is more convenient to handle and finishes off much better than the bituminous mix on these thin patches.

Applying the Bituminous Concrete.—After the feather edge paint patch has been made on the outer edges of the depression, the bituminous concrete is applied. This is done by two men, the wheelbarrow man and the finisher. The wheelbarrow man brings the bituminous concrete to the depression in a wheelbarrow. Two wheelbarrows should be used, as the marker and sweeper will have time to load the empty wheelbarrow while the other is being emptied.

The wheelbarrow man must place the bituminous concrete where the finisher wants it, namely: close to the feather edging or on the edge of the bituminous concrete previously placed. It is then worked over into place toward the center by the finisher, using the finishing shovel, until a uniform surface is obtained.

The bituminous concrete in any one depression is usually of one size mix, but if the depth of the depression becomes deeper than 1¼ in. at any place, a mix made of 1½ in. aggregate should be used in these spots. In a case like this, the outer edges of the depression would be taken care of with the feather edge paint patch, the next portion from ¼ in. to 1¼ in. in depth, with the No. 3b mix, an. the portion over 1¼ in. deep, with the No. 34 mix. It is not best to try and use the No. 34 mix to take care of the whole depression as it will contain too many large stones to give a satisfactory and even surface.

Finishing the Patch.—There are several things about finishing the patch and obtaining a smooth surface which should be mentioned. The foreman and finisher should insist that the bituminous concrete be not dumped into the center of the depression in a pile. See that it is applied by the shovelful just where the finisher wants it. This allows him to shovel it into place with his finishing shovel by pushing it off of the portion already placed, to the surface of the depression. This

tends to spread the bituminous concrete more uniformly and eliminates any high or low places after the patch has compacted.

The finisher should always keep his finishing shovel in good shape, so that it will do good work. Often he will find it necessary to remove the gummy substance which will collect on the point of his shovel. This can be done very easily by burning it off in the fire box of the tar kettle. In doing this he should be careful and not ruin his shovel by getting it too hot.

When spreading the bituminous concrete in cool weather, the finisher will find it pays to heat his shovel every few minutes, in order to get a good smooth finish to his patch. Usually the sun is hot and glaring when this work is being done. The finisher can relieve his eyes and also judge much better the smoothness of his patch if he will work with the sun to his back as much as possible. Looking down on the patch from this direction does not cause a glare and the uneven places are much more easily detected.

When the weather is very hot and the bituminous concrete has a tendency to be picked up by traffic, a small amount of clean stone (¾ in. to ¼ in.) hand scattered thinly over the fresh bituminous concrete will stop this. When the depth of the patch is under 1½ in. we do not tamp the bituminous concrete, but allow the traffic to do the compacting.

Until the finisher is thoroughly acquainted with his work and his eye has been trained to detect the slightest irregularity, he should always test his patch with a straight edge before leaving it. The foreman should not trust too much to the finisher's eye, but should satisfy himself completely that the patch is made satisfactorily.

BITUMINOUS TREATMENT OF GRAVEL ROADS IN WYOMING.—Z. E. Sevison, State Highway Engineer of Wyoming, gives the following in *Roads and Streets:*

The Wyoming Highway Department completed during July and August, 1925, the treatment of two sections of gravel surfaced roads near Laramie with results which indicate that the methods followed are adaptable on many of the other surfaced projects in the state. Numerous severe rains during the time the work was under way made it more difficult to secure uniform results and increased the cost somewhat.

Description of Projects.—These two projects are described as follows: Federal Aid Project No. 153, consisting of 3.94 miles of the Laramie-Cheyenne Road extending easterly from the end of F. A. Project No. 33, and ending in Happy Jack Canyon. This project was surfaced in 1924 with disintegrated granite commonly called Sherman Hill gravel, using the standard Wyoming section of 7 in. at the center and 3½ in. at the edges, compacted thickness, requiring 1,711 cu. yd. per mile, the average haul being 5.26 miles.

The second project consisted of 2.0 miles near the center of Federal Aid Project No. 152, which extends north from the city limits of Laramie. This project was surfaced in 1923 with pit run ¾ in. maximum size river gravel averaging rather high in grading under ½ in. The surfacing section was the same as for Project 153. About 15 per cent binder had been added during construction but this particular section, which runs through a gypsite soil, had never compacted satisfactorily and could not be maintained due to its breaking up under traffic. It was thought that this would prove as severe a test of road oiling as could be selected.

Method of Procedure.—Some variation was made in the methods followed on parts of these two projects in order to develop a procedure that would give the best results. As a result of this work of an experimental nature it was found that a firm, smooth surface easy to maintain could be produced.

The gravel surface is first scarified to a uniform depth of about 3 in. for the full width (18 ft.) and then shaped to a uniform cross section with a heavy blade grader. There is then applied 0.5 gal. of oil per square yard over one-half of the surface. The distributor is immediately followed up with a tractor and blade which cuts off the surface to the depth the oil has penetrated, generally about 1 in., and shovels it to the center of the road. The distributor then applies another application of oil to the freshly bladed surface, giving it as much as will readily penetrate, which will be from 0.2 to 0.5 gal. per square yard. The tractor and blade are then used to spread the mixture of oil and gravel that was bladed to the center back over the freshly oiled sub-surface. This method is then followed for the other half of the road and finally if the resulting mixture does not appear uniform the whole surface may be given further blading so as to manipulate the oil and gravel until every particle of gravel is coated with oil.

It was found that this process of manipulation and distribution of oil on the sub-surface will produce a uniformly treated surface 1½ to 2 in. in depth, and one which will not seriously "mat" under traffic with proper maintenance.

Costs.—The total length treated on Federal Aid Project 153 was 3.94 miles and the amount of oil used per square yard was 0.57 gal. The costs on this road were as follows:

Engineering	$ 30.64
Repairing surface	136.00
Hauling and distributing oil	272.61
Manipulating oil and gravel	367.33
Oil, 25,637 gal.	1,281.85
	$2,088.42

Cost per mile, 18 ft. road—$530.05.
Average haul of oil—6.0 miles.
Weather conditions unfavorable, amount of oil used is low but probably characteristic of surface.

The total length treated on Federal Aid Project 152 was 2 miles, and the amount of oil used was 0.68 gal. per square yard. The costs were as follows:

Engineering	$ 18.39
Repairing surface	75.60
Hauling and distributing oil	123.35
Manipulating oil and gravel	263.63
Oil	838.25
	$1,319.22

Cost per mile, 18 ft. road—$659.61.
Average haul of oil—4.5 miles.
High cost due to very unfavorable weather conditions.

The entire cost, excepting the oil, varied from $200 to $240 per mile. The oil cost 5 ct. per gal. at the refinery in Laramie.

It is realized that a final conclusion as to the value of this treatment cannot be reached until after the projects have gone through the Winter, but the experience on Project 33 treated in 1923 indicates that these projects should be in good condition at the end of one year. It is probable that re-treatment to the extent of reshaping and applying about ¼ gal. per square yard will be necessary at the end of one year, and subsequent re-treatments will be dependent on traffic and weather conditions.

BITUMINOUS SURFACE TREATMENTS, SUMMARY OF PRACTICE.—C. N. Conner, Chairman, Low Cost Improved Roads Investigation of Highway Research Board, gives the following in *Roads and Streets:*

We find three principal methods of bituminous surface treatment. They are: (1) The Skin Surface Treatment or Penetration Method, Hot or Cold; (2) the Mixed in Place Method, Cold; (3) the Premixed Method, Hot or Cold. Each of these principal methods has its advocates and is subject to variations in the classes of bitumen and aggregates used. A brief description of each will be given.

Skin Surface Treatment or Penetration Method.—This method is generally used on well compacted dense bases which do not have a loose surface.

The bituminous materials are a cold bitumen for the first, or prime, coat; generally a cold tar, a cut-back asphalt or low viscosity road oil. The second application may be a second prime coat of the same bitumen. The seal coat is generally a heavier bitumen, such as a hot asphalt, hot tar, a cold cut-back asphalt or a heavy road oil. The aggregate for cover material range all the way from a coarse clean sand to ¾ in. stone or slag. Cover material should be hard and durable.

Construction methods are simple and consist of: (1) Cleaning the base. (2) The application of a prime coat of low viscosity bitumen. (3) Ten hours to several days to allow penetration. (4) A second prime coat of the same bitumen may be advisable for the more porous bases. (5) A light cover may or may not be used on the prime coat. Better penetration results, when not used, as the cover takes up some of the bitumen. Traffic requirements may make the cover necessary. (6) and (7) The last application of the heavier bitumen and cover of sand, gravel, stone or slag. The so-called inverted penetration method means that the bitumen is applied before the final cover. The inverted method is the more common practice. (8) The surface thus formed may or may not be rolled. Best practice calls for rolling with a light or heavy power roller. A heavy roller should not be used on a relatively soft aggregate. (9) Seal coats or a third application are sometimes used to seal the surface if open or to build up a greater thickness.

Maintenance methods include retreatments, patching, scarifying, reshaping and retreating of the original surface treatments.

The cost of the first year's treatment will be considered as the original cost. This will naturally vary with the cost and class of materials used. Asphalts generally cost less than tars. Cut back asphalts cost more than road oils. Sand for cover costs less than stone. Annual scarifying, reshaping and light retreatments may add to the maintenance cost. A smoother riding surface is obtained than when a large number of small patches are used. The skin surface treatment for the first year, as here described, will cost from about $1,000 to $2,500 per mile for an 18 ft. width. The annual maintenance cost is subject to many variables of climate, materials, base, traffic, thoroughness and intelligence of maintenance. When serving within its traffic capacity the annual surface maintenance cost does not exceed $1,000 per year under unfavorable weather conditions. Under favorable weather conditions and on excellent bases the maintenance cost will not exceed $500.

The traffic capacity of this type under favorable conditions of base and climate is probably 2,000 vehicles per day, without excessive maintenance. Higher capacities have been reported. A fair average traffic capacity on gravels and top soils is from 800 to 1,500 automobiles and light trucks. A higher limit may be reached on lime rock or stone macadam bases. Examples of this type of surface may be found in use from Maine to Florida, in California and Oregon, and in portions of the Middle West.

The Mixed in Place Method, Cold.—This is a method that is new, within three or four years. Its purpose is to consolidate the existing loose or unstable aggregates by mixing them on the road with bitumen. Surfaces containing such aggregates as crushed or screened gravel, stone and sand clay or sand loam have been thus improved.

Either asphalt or tar have been used as bitumen. In a few instances both have been used. They range all the way from fuel oils as used in California to cut back asphalts in North and South Carolina and tars in Wisconsin. The bitumen should be such that it will not become sticky or "set up" until sufficient time has elapsed for the necessary manipulation of the mixture. The road oils which do not contain a solvent set up more slowly than the cut back asphalts. They also leave a more plastic mixture. The surfaces which contain such aggregates as crushed or screened gravel and crushed stone have generally been selected for treatment. There is evidence, however, that poorer materials, such as sand clay, may be thus sufficient stabilized and its traffic capacity increased.

Construction methods are briefly listed below and are subject to some variations in different parts of the country. (1) Smooth the existing surface. (2) Scarify if necessary, harrow, machine and shape. (3) Apply first coat of cold bitumen and mix with harrow and road machine blade. Sometime harrowing is omitted. Blading is seldom omitted. (4) Apply second coat of bitumen and mix thoroughly. (5) Sometimes a third coat is applied followed by more mixing. (6) Mixing is continued until a uniform color results. (7) Following a final shaping with a road blade or a drag the surface preferably is rolled for final compaction with a power roller. Some engineers secure compaction by traffic. (9) A seal coat may be used if needed. An open surface may indicate this necessity or a lean base may be the indication.

These surfaces are built as thin as about 1 in. and as thick as 3 in. Maintenance methods may include seal coats or patching with a mixture of aggregate and bitumen. If the original mixture was too lean, a remixing with more bitumen may be indicated; if too rich, a remixing with more aggregates may be the solution.

For an 18 ft. width of treatment the cost will range from $1,100 or $1,200 per mile to $5,000 or $6,000. The class of bitumens used as well as the depth of treatment will affect the cost. Most of the surfacing has been on gravels and stone roads. The first cost for these has averaged less than $2,000 per mile.

Some of these surfaces are carrying a counted traffic of between 1,000 and 2,000 vehicles per day without signs of serious fatigue. The surfaces are smooth and comfortable to ride upon, much smoother than the average skin surface treatment or rolled hot top. The mixed-in-place surfaces may be built without serious interruption to traffic and the inconvenience of heating operations. This type of surfacing may be seen in service, but with some variations in construction methods in California, Wisconsin, Indiana, Tennessee and North and South Carolina. Although the sand oil roads in Long Island are a mixture of fine gravel, sand and loam with a slow curing oil the foregoing construction methods do not apply as closely to them. The construction and maintenance operations eventually build up a mixed in place surface after two or three years.

The Premixed Method, Hot or Cold.—This class of surface treatment is in reality a thin surface course as we have been accustomed to consider surface or

wearing courses, such as bituminous concrete and sheet asphalt. By laying them thinner than standard practice or by using local materials it is expected to secure a surface whose first cost is less than $12,000 or $15,000 per mile. Included in this classification are such hot mixes as sheet asphalt and bituminous concrete of the fine and coarse aggregate types. The laid-cold surfaces are cold-patch bitumens, cut-back asphalts and road oils premixed with aggregates. Your association knows and engineers know that natural rock asphalts are a competing material within certain freight zones. They may also be classed as premixed cold surfaces.

For the hot mixtures standard specifications describe suitable bitumens and aggregates. The cold mixtures for surfacing are newer. Specifications for them are not as well standardized as a whole. Specifications for Amiesite and cold patch mixtures which may be used for surfacing are available, as are also those for Uvalde Rock Asphalt, Alabama Rock Asphalt and Kentucky Rock Asphalt. Some experimentation and a little usage indicate that there is a possibility of producing an "unnatural" or synthetic rock asphalt. That is, one which may have many of the characteristics of sand rock asphalt.

If the applied surface mixture is to be less than about 1½ in. in thickness and the base is porous or semi-porous then a prime coat of suitable cold asphalt or tar is recommended. A binder course of "black base" or a thin course of penetrated stone will add to the stability and assist in keying the top to the base. In one state, Michigan, both the prime coat and binder course are used on gravel base. The top course is stone filled sheet asphalt or fine aggregate type. The construction of the top itself varies very little from standard methods as found in The Asphalt Association Specifications. They include proper dumping, spreading, raking, patching and rolling. Final compaction by rolling must be secured in less time for the hot mixes than for the cold.

This class of surface treatment is generally maintained by patching with the same material as in the surface or by cold patch mixes.

The aim in this class of surfacing is to secure a surface which will cost less than $1.00 per square yard, or about $10,000 per mile of 18 ft. width. Rock asphalt has been laid in Texas for a ½ in. depth at $3,700 per mile, 1 in. for $5,400, including a prime coat of oil. In Michigan a prime coat of tar, a light binder course and a 2 in. "Topeka" top is costing around $13,000 per mile. Some work in Georgia using about 2 in. of penetrated stone and about ¾ in. sheet top cost approximately $12,000. When local materials may be used as aggregates the costs have been considerably reduced for the hot mixes. There is little cost or usage data available for hot or cold premixed surfaces one inch and less in thickness. Here and there are isolated sections, but Texas seems to have the largest mileage of thin premixed surface treatments.

The traffic capacity of these types on substantial bases has been estimated and counted as between 1,000 and 2,000 vehicles per day. Some are carrying more. This type of surfacing is not as smooth to ride over as the mixed in place surfaces. The cold mixes have some apparent advantages over the hot mixes. This advantage is apparent principally during the construction period. There is less interruption to traffic, less expensive equipment is required, and cost of plant operation is reduced.

Summary.—As a summary of the surface treatment situation, based on observations of usage and a study of present practice and conditions, it appears: (1) That surface treatments should not be less than 18 or 20 ft. in width and preferably from shoulder to shoulder. (2) That flat crown of ⅜ to ½ in. to the foot are sufficient for drainage. Flat crowns add to the comfort and safety of automobile travel. (3) That a cold prime coat of bitumen should precede a bituminous surface treatment on a compacted base. (4) That a hot or cold treatment may be used as the final application. (5) That a surface treatment method which includes blading is smoother riding than one which is rolled only. (6) That cold surface treatments of the mixed-in-place and premixed methods offer a wide field for immediate and future business. (7) That there is a need for standardization of names for surface treatments; and of specifications for materials, tests and methods of construction.

The surface treatment field is continually changing in character and territory. Its character is being changed by improved quality of workmanship and methods. The territory is growing to include larger areas and new fields. In the future we shall see a great number of highway departments employing engineers of training and experience as supervisors and foremen, a closer contact between laboratory and field surface treatment work, and a greater amount of surface treatment work let to contract.

Macadam Street Maintenance Cost Data

REPAIR AND MAINTENANCE OF MACADAMIZED STREETS.—B. C. Harvey, City Engineer of Rockford, Ill., gives the following in *Roads and Streets:*

There are still many cities in the country in which a large proportion of the paving is water-bound macadam. The maintenance of streets of this type offers a big problem to street departments because of the ever-increasing motor traffic and the heavier transportation units. The city of Rockford has aimed to organize its maintenance and repair work in such a way as to minimize the necessary expense and to keep the streets in first-rate condition. A very careful cost system is maintained, so that as nearly as possible the exact cost for each piece of work is known.

How Streets Are Paved.—There are 216.119 miles of streets, of which 139.729 miles are improved and 76.39 are unimproved. The improved streets are composed of the following type of pavement:

	Miles
Brick	20.414
Concrete	18.716
Resurfaced	13.505
Warrenite	5.581
Asphalt	1.85
Water-bound Macadam	57.951
Bituminous Macadam	21.712

Repair and Maintenance Equipment.—The city of Rockford owns and operates the following equipment for repairs and maintenance:

Two 12-ton Kelly-Springfield road rollers with steam scarifier attachment
One 3½-ton G. M. C. truck
One 3½-ton Master truck
One 3½-ton Republic truck
One 3½-ton Diamond T truck
One 2-ton Republic truck
One 2-ton Master truck
One 5-ton Holt Carterpillar tractor
One original design stone spreader
Two 2-ton Republic trucks with trailers equipped for street patrol work
One portable air-compressor, together with a very modern quarry and stone-crushing plant equipped to manufacture from 20,000 to 50,000 cu. yds. of stone yearly.

Organization.—The department is 100 per cent motorized, and skilled mechanics are engaged to operate the equipment. The average age of the men employed in the department is 40, which is low for a municipal organization. There is one superintendent of streets, one street foreman on resurfacing work, one street foreman on oiling (this man being a tractor-operator), one master mechanic who is responsible for the equipment and one quarry superintendent.

The Quarry.—The city owns and operates a quarry. The stone which is crushed at the quarry is a very hard, durable limestone. The crusher jaws are set to give four different grades of material: No. 0 material, which is dust; No. 1 material, ranging from ¼ to ½ in. stone; No. 2 stone, which ranges from ½ to 1¼ in.; and No. 4, which ranges from 1¼ to 2½ in.

Resurfacing Old Macadam Streets Using Double Seal Method.—The old water-bound macadam streets which are beyond repairing by the surface treating method are scarified to a depth sufficient to either raise or lower the crown and quarterpoints of the streets. The loosened base is then graded and thoroughly rolled, leaving a smooth and firm base. Stone ranging from 1¼ in. to 2½ in. is spread over the area to a depth of 3 in. This stone is then rolled and compacted enough to allow a heavy truck to drive over it without causing deep ruts.

Bituminous material heated to a temperature ranging from 300 to 325° F., using 110 penetration asphalt, is applied at the rate of not less than 1½ gal, nor more than 1.8 gal. per square yard. No. 2 stone, or stone ranging in size from ½ in. to 1¼ in. is then spread uniformly over the whole surface, filling all voids.

This course is then thoroughly rolled, leaving a firm, uniform surface. The roadway is then swept free from all loose particles of stone not held by the bituminous material. Then, not less than ½ gal. nor more than ¾ gal. per square yard of the same kind of bituminous material is applied, heated to the above described temperature. No. 1 stone, or stone ranging from ¼ in to ½ in. in size is then uniformly spread over the surface.

The roadway is then thoroughly rolled again. Then the same kind of bituminous material heated to the same temperature as before specified is applied at a rate of not less than ¼ gal. nor more than ½ gal. per square yard. Small gravel, known as pea gravel is then uniformly spread over the surface. The surface is then rolled again until the bituminous material has a tendency to show through the gravel. This method has been found very successful, and after a few months of travel the streets look very similar to sheet asphalt pavement.

Cost of Resurfacing.—One season 2.276 miles of streets were resurfaced, as described above and at a cost shown in detail below:

		Per sq. yd.
Rolling and scarifying 1,060 hours at $1.50 per hour	$ 1,590.00	$0.039
Grading roadway after being scarified, 64 hours at $2.00 per hour	128.00	.003
Labor for spreading stone and building up sub-grade, 3,132½ hours	1,900.21	.046
Stone—6,806½ cu. yds. of crushed stone, delivered to job at $1.75 per cubic yard	11,911.38	.291
Gravel—73½ yds. pea gravel delivered to job at $2.00 per yard	147.00	.004
Asphalt—106,147 gals. of 110 penetration asphalt applied at 11.5 ct. per gallon	12,206.92	.297
Road oil—5,000 gals. of 45 per cent asphalt applied at 10.7 ct. per gal	535.00	.013
Total Cost	$28,418.51	$0.693

Number of square yards resurfaced was 40,995.
Cost per square yard was $0.693.
The average number of gallons of asphalt used per square yard was 2.71 gals.
The bid price on 110 penetration asphalt was 10.98 ct. applied, and the bid price on road oil was 10.65 ct. applied.

The next season 0.653 miles of streets were resurfaced, as described above and at cost shown below:

		Per sq. yd.
Rolling and scarifying 270 hours at $1.50 per hour	$ 405.00	$0.036
Grading roadway after being scarified, 61½ hours at $2.00 per hour	123.00	.010
Stone loader—22 hours loading stone and dirt	58.30	.005
Truck service—77 hours, hauling dirt at $1.50 per hour	115.50	.010
Labor loading dirt—78½ hours	49.47	.004
Gravel—52¾ yds. pea gravel delivered to job at $2.00 per yard	105.50	.010
Stone—1,322.22 cu. yds. of crushed stone delivered to job at $1.60 per cubic yard	2,115.56	.187
Labor for spreading stone and building subgrade, 985 hours	631.95	.056
Asphalt—27,615 gals. of 110 penetration asphalt applied at 10 ct. per gallon	2,761.50	.245
Total Cost	$6,365.78	$0.563

Number of square yards resurfaced was 11,289.
Cost per square yard was $0.563.
The average number of gallons of asphalt used per square yard was 2.44 gals.
The bid price on 110 penetration asphalt was 18.90 per ton F. O. B. Rockford.

In the costs as recorded above, interest on the investment of equipment together with the depreciation on the equipment is included. In the cost of the asphalt, car demurrage and cost of steam and clerical work are included.

Surface Treatment of Macadam Streets.—The surface-treating or oiling crew is composed of the superintendent of streets, who acts as supervisor, one foreman, who is also the tractor operator, two laborers, and four truck operators. The equipment consists of one 5-ton Holt Tractor, one stone spreader, designed by the writer and made by the street department, and generally four trucks, though on some occasions only three trucks are necessary, depending on the length of haul. Two of the trucks are owned by the city of Rockford, and the other trucks are hired from the company from which material is purchased, based on cost per yard delivered.

When macadam streets are to be surface treated, they are first thoroughly swept. The method of cleaning consists in sweeping the surface with two motor-driven Elgin pick-up sweepers. Two one-ton Ford trucks are used for hauling the sweepings to the dump. The two truck operators and two laborers clean all places not accessible to the sweeper and shovel all rubbish into the trucks and haul it to the dump. The cost of cleaning is charged against the street-cleaning fund. The average cost per 1,000 sq. yds. for cleaning all streets the first year was 41.48 ct. The next year up to Sept. 1st, 29,037,129 sq. yds. were cleaned at a total cost of $11,615.95 or 40 ct. per 1,000 sq. yds.

The bituminous material is applied at a rate depending upon the condition of the surface of the roadway. The average rate of application the first season was approximately 0.15 gal. per square yard, and the next year the average rate of application was 0.22 gal. per square yard. Finely graded gravel, known as pea gravel, is then uniformly spread over the surface of the roadway by the stone spreader, which operates uniformly to a width of eight feet. The stone spreader is drawn by the 5-ton Holt tractor. The two laborers assist with loading the stone spreader and scatter extra gravel whenever necessary. The gravel is dumped directly into the stone spreader. We have surface treated as much as 27,232 sq. yd. of pavement in one 8-hour day.

Cost of Surface Treatment.—The first year a total of 61.647 miles of macadam streets was surface treated, making a total of 1,113,826 sq. yd. The total cost for this work was $25,258.41 or a cost of $0.02267 per square yard. The cost of cleaning streets prior to surface treating is not included in this cost. The cost of surface treating is figured as follows:

OILING OF STREETS

First Season

Oiling with Road Oil

Miles of streets oiled	0.534
Gallons of oil used—2,425 gals. @ 10.7 ct. per gal	$ 259.48
Number of square yards oiled	7,724
Cost per square yard	0.0335

Oiling with 4-B Asphalt

Miles of streets oiled	0.253
Gallons of asphalt used—1,300 gals. @ 11.5 ct. per gallon	$ 149.50
Yards of sand—9 yds. @ $1.00 per yard	9.00
2 yds. of pea gravel @ $2.00 per yard	4.00
Labor spreading sand and gravel	18.60
Total Cost	$ 181.10
Number of square yards oiled	3,201
Cost per square yard	0.0565

Oiling with 3-B Asphalt

Miles of streets oiled	10.95
Gallons of asphalt used—32,824 gals. @ 10 cts. per gallon	$ 3,282.40
232½ hours labor	143.19
433½ yards of pea gravel @ $2.00 per yard delivered	867.00
77½ yds. of No. 1 stone @ $1.00 per yard	77.50
72 hours labor spreading stone and dust and hauling same	144.00
63 yds. of sand @ $1.00 per yard	63.00
41 hours labor hauling and spreading sand	82.00
Total Cost	$ 4,659.09
Number of square yards oiled	185,870
Average cost per square yard	0.0250

Oiling with Tarvia B

Miles of streets oiled	49.91
Labor	$ 469.89
Tractor	260.25
1,891½ yds. of pea gravel @ $2.00 per yard	3,783.00
130,545 gals. of Tarvia B @ 12 cts. per gal	15,645.60
Total Cost	$20,158.74
Number of square yards	917,031
Average cost per square yard	0.0219

Total Oiling

Miles of streets oiled	61.647
Total Cost	$25,258.41
Number of square yards oiled	1,113,826
Average cost per square yard	0.02267

It will be noted that different grades of bituminous material have been used for this work, the purpose being to determine which will give the best results. The materials used have been Tarvia B, Texaco 110 penetration asphalt, road oil and Indian Refining Co. 200 penetration asphalt.

If all surface treatment had been applied on an 18-ft. roadway, it would cover a distance of 556,913 lin. ft., or 105.47 miles.

First year, for experimental purposes, after some of the streets had been thoroughly cleaned, the pea gravel was spread first, after which the Tarvia B was applied. From our observation the experiment has been successful and especially for a high-crowned street, as the gravel does not have a tendency to roll down toward the gutter.

Oiling with Tarvia B—Second Season

Miles of streets oiled	22.908
Labor	$ 214.98
Tractor	116.00
700.1 yds. of pea gravel @ $2.00 per yard	1,400.20
73,933 gals. of Tarvia B @ 12 cts. per gallon	8,871.96
Total Cost	$10,603.14
Number of square yards oiled	335,399
Average cost per square yard	$ 0.031

During 1925 the gravel was spread on the road surface prior to oiling except at such times as we were unable to keep ahead of the oiler. It must be admitted, however, that this method consumes more bituminous material, but we are satisfied that it gives the roadway a better wearing surface.

Street Patrol Maintenance.—The two street maintenance patrols are made up as follows: Two 2-ton Republic trucks, on each of which is mounted a tar kettle having a capacity of 135 gal. The kettle is mounted at the rear of the truck. Two sheets of asbestos are placed on the truck body, over which is placed a sheet of 16-gauge iron. Removable side-boards are placed between the cab of the truck and the kettle. In this space is kept a steel barrel which contains bituminous material that is applied cold. The rest of this space is used for stone. The 2-wheel trailers are the type used by the aviation branch of the Army and were made into substantial trailers for hauling different sizes of stone. The front end of the trailer box was made pointed to assist in making shorter turns, and in this portion are kept the tools, picks and shovels. A cover is placed over this end, and a slot is cut in the face part to allow the tools to be kept under lock and key. On either side of the truck cab Pyrene fire extinguishers are mounted. The cost of the street patrol outfit was as follows:

2 2-ton Republic trucks (second-hand) 1,000 each	$2,000
2 135-gal. capacity kettles at $200 each	400
2 trailers at $91 each	182
Lumber and materials	80
Labor	88
Total cost of two street patrols	$2,750

The organization for this work consists of two foremen, two kettle tenders, two truck drivers, and two skilled mechanics. Each street patrol has a certain por-

tion of the city to look after and must confine itself to macadam streets, to patch any and all surface breaks, and to repair all utility service ditches caused by the installation of sewer, water, gas, electric, telephone or telegraph services. A flat rate of 20 ct. per square foot is charged against any and all utility firms, corporations, or individuals. The city sewer department and city water department must pay to the street department the cost of 20 ct. per square foot for all ditches patched.

Suggestions for Penetration Work.—To obtain excellent results in penetration work, use a very good durable crushed limestone, granite or gravel free from dust and organic matter. When using gravel be sure that at least 60 per cent of the gravel is crushed or broken to insure a mechanical bond. Do not roll the stone until it fractures and pulverizes before asphalt is applied, as this will not permit the penetration of the asphalt. The asphalt should fill the voids in the stone. Do not attempt to apply asphalt on a damp or wet surface. The asphalt should have the proper melting point and penetration which is governed by the climate and traffic. Asphalt should be heated to a temperature of not less than 300° F. nor more than 350° F. Use steam heat where possible. Make the surface as smooth as possible. Use a 10 ft. straight edge to insure a smooth and lasting surface and last of all do not make excessive crowns. Invite your traffic over the whole area of your street.

METHODS AND COST OF RESHAPING AND OILING MACADAMIZED STREETS AT PORTLAND, ORE.—O. E. Stanley, Chief, Bureau of Maintenance, Department of Public Works of Portland, Ore., gives the following in *Roads and Streets:*

The reshaping process consists of scarifying the surface of the macadam with a pressure scarifier attached to a 10-ton road roller, restoring the cross section of the roadway so far as may be possible by shovels and a "land leveller" without the addition of new material, thoroughly wetting the street and compacting it with the 10-ton roller.

Traffic is allowed to use the street during and immediately after the reshaping, but it is believed better results would be obtained if the streets might be closed for a day or two to allow the surplus moisture to dry out.

The reshaping work is carried on almost continuously through the year, only stopping for a few weeks in the winter during freezing weather. The equipment is overhauled during this cold weather when it cannot be used on the street.

Oiling.—After the streets have dried out and the ground has become thoroughly warmed in the spring, from the middle of May to the first of June, oiling is commenced.

Fuel oil, containing 50 per cent or more of asphaltum is used. This is hauled from the oil company's plant in the city's truck which is equipped with a spreading device, covering a width of 6 ft. of roadway at a trip. The edges of the roadway within 4 ft. of the curbs are not oiled but are included in the yardage reported. This fact should be noted in using the figures in Table I as it will increase the gallons per square yard of oil used on the surface actually covered by about 25 per cent. A little more than ¼ gal. of oil per square yard of roadway is used.

As soon as the street is oiled, clean sand is spread by hand at the intersections to make crosswalks. This sand is left in piles by a 1-ton truck, in advance of the oiling. Such traffic as desires to use the freshly oiled streets is allowed, and after a day or two is an actual benefit, as it presses the thickened oil into the surface of the street.

The oil is not applied until the film of fine material which comes to the surface as a result of wetting and rolling the macadam has worn off. If this film of caked dust were to be oiled, it would absorb the oil and be easily broken up and worn away by traffic. If allowed to wear and blow away before the oiling, the oil binds the particles of rock and makes a durable surface.

Labor Organization and Wages.—The reshaping gang consists of a sub-foreman who works with the men, a steam roller driver, a tractor driver and four laborers.

In the oiling crew are two truck drivers (one on the oiler and one on the 1-ton sand truck) and two laborers. One of the laborers manipulates the levers regulating the flow of oil and the other one helps the driver unload sand from the small truck. When the Fordson tractor is not busy pulling the sprinkling wagon, hauling coal for the steam roller, or working with the land leveller, the driver works with the other laborers brooming back the "soup" which the roller brings to the surface of the macadam, from the gutter to the crown of the street.

The men are paid the following wages:

Sub-foremen	$5.10 per day
Steam roller drivers	7.29 per day
Tractor drivers	5.10 per day
Truck drivers	5.10 per day
Laborers	4.60 per day

The roller is charged against the job at $1.34 per hour, the tractor at 40 cts., the oiler at 92 cts. an hour, and the 1-ton Ford used to distribute sand at 37 cts. an hour.

In addition to these charges, each gang carries indirect and overhead charges as follows:

Indirect labor, to cover cost of holidays and vacations of the men in the gang, $3.41 per day.

Miscellaneous supplies, repair of tools for the gang, a share of the expense of general foreman's auto, car fare and stationery, $1.08 per day.

Depreciation of tools and equipment, including a share of the general foreman's auto, supervision by general foreman, and prorated time of chief of bureau, $3.95, a total of $8.44 a day above the direct labor materials and equipment charge. Table I shows the cost of macadam street maintenance.

It is believed that after a general reshaping of the macadam streets, most of them can be kept in repair by patching at a less cost, but there are some heavily travelled streets that will require reshaping every year until they are paved with a more durable covering. Many of these streets had had no repair work done on them for 8 or 10 years.

TABLE I—MAINTENANCE OF MACADAM STREETS

Streets Reshaped

Square yards reshaped	883,348
Total cost	$32,404.58
Unit cost	$0.0367

Streets Oiled

Square yards oiled (first oiling)	882,797
Total oiling cost (labor and materials)	$12,423.74
Unit cost (labor and materials)	$0.0141

Streets Re-oiled

These had been oiled the year previous or early in the season.

Square yards re-oiled	416,704
Total re-oiling cost	$3,006.50
Unit re-oiling cost	$0.0072

Oiling Materials
(42 gal. of oil to the barrel)

	Bbls. Oil	Cost	Yds. Sand	Cost	Total Material Cost
Oiling 813,104 sq. yds.	5,014	$8,273.10	293½	$249.48	$8,522.58
Per square yard	.0062	$0.0102	.00031	$.00026	$0.01046
Re-oiling 416,704 sq. yd.	1,108	$1,828.20	233	$198.05	$2,026.25
Per square yard	.0026	$.00429	.00056	$.000476	$0.000532

ACME ROAD MACHINERY COMPANY, INC.

Main Office and Factory—Frankfort, N. Y.

Manufacturers of Road Building and Quarry Equipment

Branch Factory—Salem, N. Y. Branch Offices—120 Liberty Street, New York City; 65 Broadway, Cambridge, Mass.

Products: ROLLERS, 3-WHEELED, 5 TO 15 TONS, TANDEM 5 TO 9 TON, SAME HORSE OR TRACTOR DRAWN; SCARIFIERS; PORTABLE AND STATIONARY CRUSHERS; ELEVATORS; QUARRY CARS; ASH AND GARBAGE WAGONS; LOW GEAR TRUCKS; CONTRACTORS' DUMP CARTS; WATER WAGONS; CONCRETE MIXERS; SCREENS; CONVEYORS; BINS; SAND AND GRAVEL SCREENING AND WASHING PLANTS; UNLOADING PLANTS; WAGONS, DUMP AND SPREADING; GRADERS, POWER AND HORSE OR TRACTOR; STREET SWEEPERS; GARBAGE CARTS; SPRINKLING WAGONS; AIR COMPRESSORS.

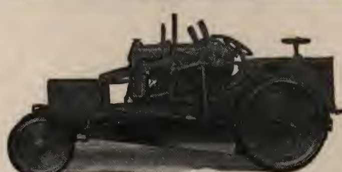
Rollers: Acme was the pioneer and is still the leader in the gasoline road roller field. Engineering features of design and construction provide economies of operation and added durability found in no other rollers. Heavy duty bearings, in continuous oil bath, throughout. Light weight Acme gas rollers manufactured with three speed transmissions in both directions. Patented Acme Air Pressure Power Scarifiers are available with rollers.

General Dimensions Three Wheel Motor Rollers
Made in 4. 5, 6, 7. 8. 10 and 15 Ton Types

Ton Size	Rear Roll Diam.	Rear Roll Face	Front Roll Diam.	Front Roll Face	Compression per lineal inch rear roll	Compression per lineal inch front roll	4-cyl. Engine H. P.	Gas Tank Capacity	Length and Width, over all	Approximate Weight	Miles per hour
5 To 15	48″ To 70″	16″ To 24″	32″ To 45″	36″ To 48″	200 To 375	90 To 250	24 To 55 60	15 To 50	12′-6″ 5′-4″ To 16′-0″ 7′-8″	10,000 To 30,000	High 5 00 Low 2.75 To High 2.21 Low 1.25

On 10-12 Ton Rollers 22 in. and 24 in. face furnished on request at nominal additional charge. Compression data is weight per lineal inch on rolls.

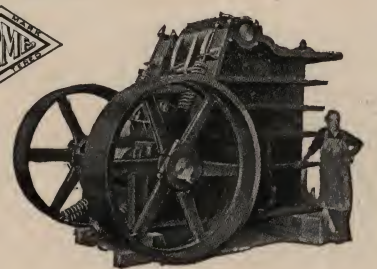
Pony Roller: 5 to 10 tons, powered with either Continental motor, McCormick-Deering or Fordson. Same type frame construction used as in the large standard rollers. Can be equipped with planer attachment, scarifier, hand or power, and bull-dozer.



Power Graders: Acme Power Grader, short wheel base, perfect balance. Heavy mouldboard planes true. Back-geared, three to one, with independent rear axle. Equipped with locking device. Can be equipped with hand or power scarifier, bull-dozer or snow plows.

General Dimensions Acme Horse and Traction Graders

NAME	Wheel Base	Mould-board	Front Wheels	Rear Wheels	Concaved Tires	Weight Lbs.
Pony	101″	6′x12$\frac{5}{16}$″	22″	30″	3″ face	1400
Junior	118″	6′x12$\frac{5}{16}$″	26″	40″	3″ face	1900
Senior	131″	7′ 3″	28″	42″	4″ face	2750
8-ft. Light	131″	8′ 0″	28″	42″	5″ face	3300
8-ft. Medium	139″	8′ 0″	28″	42″	5″ face	4000
8-ft. Heavy	139″	9′ 0″	28″	42″	5″ face	5800
10-ft. Heavy	158″	10′ 0″	32″	48″	6″ face	7500
12-ft. Heavy	190″	12′ 0″	32″	48″	6″ face	9000



Crushers: Primary, secondary, stationary, portable with folding elevator. Solid steel frame and boiler plate, are welded frame types. For contractors' and township work. Strong enough to withstand the strain of crushing the toughest and hardest rock, and yet of such weight as to be readily moved to the place where the work is to be done.

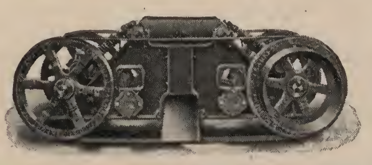
Table of Sizes, Dimensions and Weights Style A Crushers

Crusher Number	Receiving Capacity	Tons per Hour with Jaws set to Close to 2 in.	Diameter and Face of Band Wheel	Floor Space Long Wide	Speed	Weight	Horse Power	Weight Mounted Estimated	Sized Elevator Best Suited
6 To 12-A	6 x 10 in. To 12 x 32 in.	3 to 5 To 30 to 50	22 x 6 in. To 44 x 17 in.	4 ft. 1 in. x 3 ft. 2 in. To 10 ft. 8 in. x 9 ft. 6 in.	325–350 To 260–275	1800 To 30000	8 To 50	2550 To NotM't'd	6 To 12

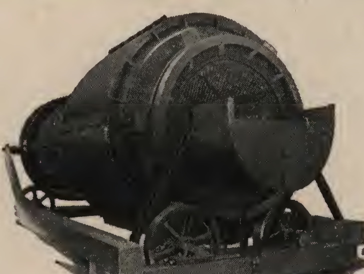
Table of Sizes, Dimensions and Weights, Style D Crushers

Number and Style	Receiving Capacity	Tons per Hour with Jaws set to Close to 2 in.	Diameter and Face of Band Wheel	Floor Space Long Wide	Speed	Weight Estimated	Horse Power	Weight Mounted Estimated	Size Elevator Best Suited
8½-D To 42-D	10 x 16 in. To 42 x 48 in.	10 to 16 To 200 to 300-12″	30 x 9 in. To 78 x 20 in.	6½ ft. x 5 ft. To 20 ft. 2 in. x 7 ft.	300–325 To 200–250	8000 To 95000	15 To 115	9078 To Not M't'd	8½ To 42

All sizes in stock or course of construction



Tailings Crusher: Primary, secondary, stationary, portable with folding elevator, solid steel frame and boiler steel plate frame; complete rock or sand and gravel plants. Our Engineering Department is always glad to cooperate in plant layout and details. Fine reduction crusher for secondary or tailings work as well as for gravel industry. Manufactured in sizes 6x10 to double 10x42. Write for catalog giving special features.



Screens: Made in all sizes either wire cloth or perforated steel plates. We carry in stock plated for screens 30, 36, 42, 48 and 60 in. in diameter. Other diameter and special perforations can be furnished promptly. Length of screens are as ordered ranging from 4 ft. to 30 ft. Screen sections are either 3, 4 or 5 ft. long. We make both shaft and roller screens in three styles I-beam roller, band roller and shaft type and head or rear driven.

Dimensions, Weights, Etc., of Screens

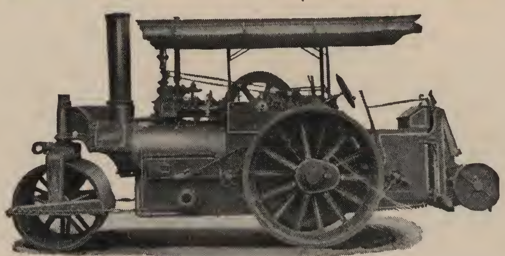
DIAMETER	LENGTH	SIZE OF SHAFT	GAUGE OF PLATE	TYPE OF SCREEN	WEIGHT	NUMBER OF SECTIONS
30 inches	6 feet	$1\frac{13}{16}$ inches	$\frac{3}{16}$ inch	Shaft	750	Stock plates 3, 4 or 5 ft.
30 inches	7 feet	$2\frac{3}{16}$ inches	$\frac{3}{16}$ inch	Shaft	846	
30 inches	9 feet	$2\frac{3}{16}$ inches	$\frac{3}{16}$ inch	Shaft	976	
30 inches	12 feet	$2\frac{3}{16}$ inches	$\frac{3}{16}$ inch	Shaft	1172	
30 inches	15 feet	$2\frac{7}{16}$ in. if used	$\frac{3}{16}$ inch	Shaft or Roller	1467	
36 inches	9 feet	$2\frac{7}{16}$ in. if used	¼ inch	Shaft	1020	
36 inches	12 feet	$2\frac{7}{16}$ in. if used	¼ inch	Shaft	1359	
36 inches	15 feet	$2\frac{7}{16}$ in. if used	¼ inch	Shaft or Roller	2100	
42 inches	12 to 20 feet	$3\frac{15}{16}$ in. if used	$\frac{5}{16}$ inch	Shaft or Roller	....	Stock plates for 42″ Screens and larger are all 4 ft. long
42 inches	12 feet	....	$\frac{5}{16}$ inch	Roller	7788	
48 inches	....	....	⅜ inch	....	....	
54 inches		Proportion				
60 inches	.....	to length	½ inch	Roller or Shaft	.	
72 inches						
84 inches	....	....	......	....	....	

THE BUFFALO-SPRINGFIELD ROLLER COMPANY

Springfield, Ohio, U. S. A.

Manufacturers of Steam and Motor Rollers

Products: THREE WHEEL AND TANDEM STEAM AND MOTOR ROLLERS; PRESSURE CYLINDER SCARIFIERS.



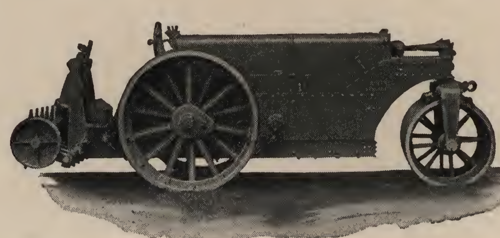
Buffalo-Springfield Three-Wheel Steam Rollers. Buffalo-Springfield three-wheel steam rollers were among the first developed in America. Used in grading and rolling earth and gravel roads and for the construction of macadam and other types of hard surfaces. They haul and furnish pressure for oil and tar tanks employed in macadam construction and maintenance. Equipped with Buffalo-Springfield pressure cylinder scarifiers, they prepare sub-grade for new construction or scarify old surfaces for reshaping or resurfacing.

When so ordered, can be equipped with special wide rear wheels for rolling asphalt and bituminous concrete pavements. Also be equipped with band wheel attachment which enables the use of roller for stationary power to run rock crusher or other machine. Coal is the normal fuel, but can be fitted to burn wood or crude and fuel oil.

Made in sizes from 10 to 20 tons.

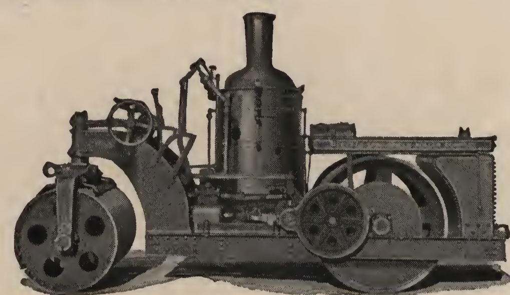
Buffalo-Springfield Three Wheel Motor Rollers have been adopted by many of the larger and more experienced users of motor driven rolling equipment. The motor is of the two or four cylinder type and free from excessive vibration. These machines have a low center of gravity and change speed gears for both forward and backward motions. This enables these rollers to perform all classes of rolling as well as heavy scarifying and hauling.

Buffalo-Springfield Motor Rollers are made in weights from five to fifteen tons. They can be equipped with pressure cylinder scarifier, also with band wheel attachment.



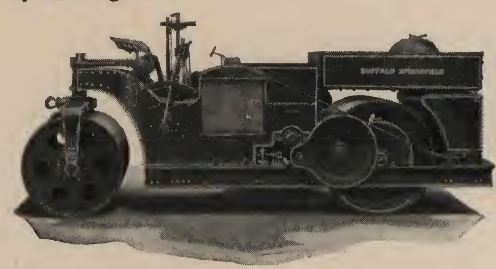
Buffalo Maintenance Rollers are built for heavy rolling and for breaking and loosening very hard and tough surfaces such as cement, asphaltic and bituminous concrete.

Loosening mechanism is about the left drive roll and is reversible, permitting working in both directions. The location of the loosening device enables heavy scarifying to be done close to curb. Scores now in the service of counties, municipalities and contractors specializing in difficult work. Modern traffic is so destructive to road surfaces that the need of heavier rollers to properly consolidate the sub-grade and surfacing material is becoming increasingly apparent. These provide increased rolling pressure for present and future demands.
Made in sizes from 12 to 16 tons.



Buffalo-Springfield Tandem Steam Rollers feature a double horizontal steam engine mounted on main frame and transmitting power to drive roll through spur gearing. This departure prolongs the life of the roller and enables it to perform many classes of especially difficult work. Used for sub-grade rolling block and plastic pavements, gravel and macadam roadways.

Made in sizes from 2½ to 13 tons. All sizes weighing over 4 tons equipped with separate steam steering engine to permit quick and easy handling.



Buffalo-Springfield Tandem Motor Rollers. Made along lines of steam tandems except that power is furnished by a two-cylinder or four-cylinder motor and is transmitted through gears giving two gear speeds in both forward and backward motions. Preferred to steam tandems where coal and water are inconvenient to obtain or when rolling is so intermittent as to make it inadvisable to keep a steam tandem ready for service at all times. Equipped with both power and hand steering gear and with a device for cooling the circulating water of the motor. Made in sizes from 4 to 13 tons.

ERIE MACHINE SHOPS

Erie, Pennsylvania, U. S. A.

Tandem Paving Rollers—Gas and Steam—Same High Quality

Products: Tandem Paving Rollers: Gasoline in 5, 8 and 10-ton sizes. Steam in 3, 5, 8 and 10-ton sizes.

Smoother operation, with perfect control, is the outstanding feature of the Erie Gasoline Roller.

Instant reversing at full speed: Two handy control levers give complete control of the forward and reverse motion, and steering—in both parallel and cross rolling. Not the slightest jerk or jar. No pushing up of hot stuff in quick reversing, **the Erie Gasoline Roller has all the flexibility of steam.**

Unequaled ease in steering: Bevel gears transmit the motor's power to the steering roll at a touch of the steering lever. The steering roll is in four sections that turn independently—preventing cutting up of the hot stuff in making a sharp turn.

Saves hand tamping costs: There is plenty of side and end clearance for rolling close to the curb— can roll right up to headers, manholes, curbs and other "tight places."

Note how the operator can roll a sharp curve with his driving roll flush against the curbing

Accuracy and safety: The operator has a clear view—nothing to block the line of vision in any direction.

Guaranteed to give smoother and harder pavements, at lower rolling costs: Gives a higher compression—the 10-ton Erie Gas Roller is guaranteed to exert a compression of 300 lbs. per square inch, and the 8-ton is guaranteed to deliver 275 lbs. per square inch.

Every Erie Roller carries our regular five-year guarantee covering both workmanship and material.

Full description, with specifications, will be sent on request.

Erie Steam Rollers are noted for Trouble-Proof Service: The Erie Steam Roller has proved, by years of successful performance, that it has the stamina to deliver trouble-proof service year after year.

The power plant consists of high pressure double-reversing engines with semi-balanced slide valves. **Instant** forward or reverse motion, controlled by the throttle.

And the engine's power is used for steering, same as on the Erie Gas Roller. Giving easy steering and perfect control in the tight places.

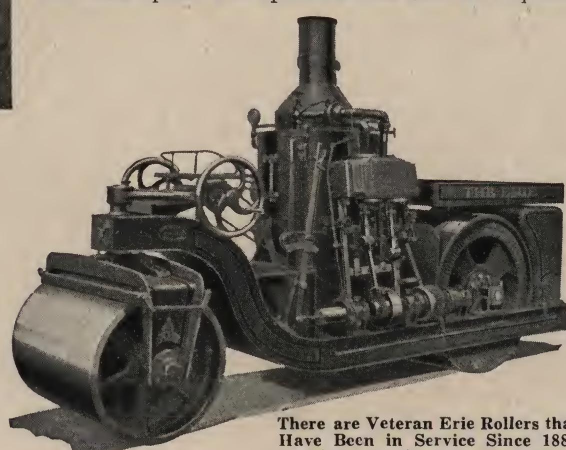
Guaranteed for five years: Due to our long experience in building steam rollers, we are able to guarantee the material and workmanship of every Erie Roller for five years. **The highest standard of construction throughout;** the cylinders, steam chest and heavy saddle are formed of one sturdy integral casting, which is bolted securely to the boiler and the frame. Roller bearings on front and rear roll shafts.

Like the Erie Gas Rollers, the Erie Steam Rollers give definite guaranteed compression.

With this guaranteed higher compression you know, first of all, that your binder course is being thoroughly compacted so as to make a sound foundation for the top. It stays put.

And the top is finished much harder, bonding firmly to the binder course—which prevents "shoving" under heavy traffic and hot weather conditions.

Full description and specifications sent on request.



There are Veteran Erie Rollers that Have Been in Service Since 1887 —and Reports from the Users Show that They're Still Going Strong

W. A. RIDDELL COMPANY

SUCCESSORS TO HADFIELD-PENFIELD STEEL CO.

Bucyrus, Ohio

Manufacturers of "One Man" Graders

WARCO
W. A. RIDDELL COMPANY
BUCYRUS, OHIO

Products: Power Graders, Rigid Rail Tracks, Snow Plows, Rooters, Scarifiers, Ditchers, Rollers, Automatic Scrapers.

A Better Built Line of Road Machinery: The W. A. Riddell Co., Bucyrus, Ohio, successors to the Hadfield-Penfield Steel Co., is building "One Man" Graders under the original basic patents. These Graders are a "Better Built" line, both center and rear control, equipped with Crawler tracks or rubber wheels. Some of the outstanding features of the line are the Independent Scarifier, Head Type Steering Gear, "I" Beam Frames, Inclosed Gears, Spring Counterbalance Lift, Reinforced Moldboard, Blade Lock, Leaning Wheel, Double End Side Crank, Tubular Lifting Arms, Dependable Circle and Circle Lock and Tractor Crawlerizers. Comparison invited. One Man is the whole Crew. Other units of the WARCO Line are Drawn and Powered Rollers, Automatic Wheel Scoops, Snow Plows, Crawlerizers for Tractors. WARCO Graders are built to do a bigger day's work with less operating and repair cost.

Model "E" One Man H. P. Grader with Head Type Steering Gear, Independent Scarifier and other late features. Tractor Crawlerized with H. P. Rigid Rail Tracks

RYAN MANUFACTURING CORPORATION

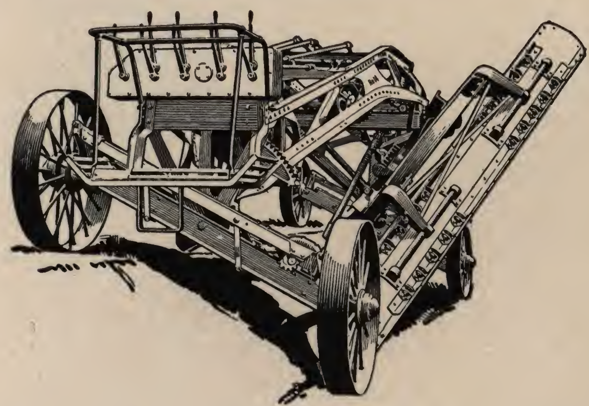
DIVISION OF THE RYAN CAR COMPANY

13501 Baltimore Avenue, Chicago, Illinois

Ryan Motor Controlled, Leanable Frame Grading Machine

Products: RYAN MOTOR CONTROLLED, LEANABLE FRAME GRADING MACHINES.

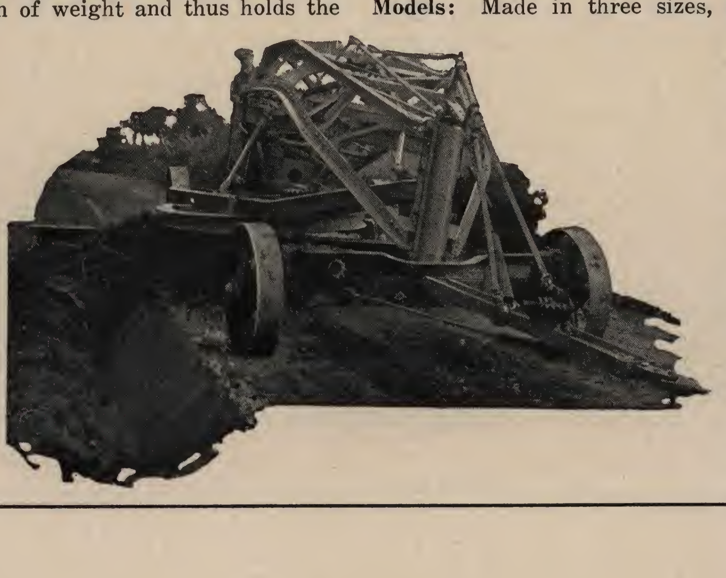
The Ryan Grading Machine is a new and highly important development in blade machines, being far in advance of ordinary graders in design, operation and performance. It presents an entirely new and useful range of blade positions which add greatly to the scope and efficiency of a grader outfit.



Motor Control: All adjustments on the Ryan machine are quickly and easily secured by motor control. The operator is relieved of the muscle-tiring work of continually pulling and tugging at hand wheels, and is able to concentrate his attention on his real job of moving more dirt in less time. A small 2-cylinder gas engine is mounted at the rear of the frame, out of the way, and its power connected to the operating shafts through clutches enclosed in a gear box just in front of the operator's platform. Control levers are convenient to operator's reach and only require pushing one way or other to secure desired adjustment.

Leanable Frame: The Ryan Grading Machine avoids increased weight on ditch wheels by leaning the frame and moving center of gravity uphill, actually transferring the weight from a **downhill** weight away from the load to an **uphill** weight against the load. This gives proper distribution of weight and thus holds the machine to its work and lightens draw-bar pull. Another reason why the Ryan will move more dirt with less power.

Exclusive Blade Positions: In addition to the increased efficiency of this machine in ordinary grading work, due to its perfect blade settings, ease of operation and proper control of weight, a complete range of high bank cutting blade positions are made possible by the leanable frame and other exclusive features of construction. High banks can be cut down with the Ryan at a fraction of the cost of other methods.



Strength: The trussed frame construction used on the Ryan is evidence of the advanced design throughout, being many times stronger than any one-piece frame. This frame is practically indestructible, eliminating for all time the frame breakage which has been a serious factor in keeping graders in operation. Castings are all of highest grade steel, and all details affecting the life and continuous operation of the machine have had most careful attention.

Flexible Front Axle Connection: A strong and simple ball and socket connection between the frame and front axle gives complete flexibility and eliminates breakage caused on ordinary graders by fifth-wheel or other semi-rigid constructions. At the same time this gives a mechanically correct pull between the hitch and the main frame, doing away with indirect draft through the old style king bolt.

Attachments: **Scarifier,** 7 staggered teeth, cast block, attaches to draw bar, and operated by motor control.

Ditch bottom shaper, for attaching to end of mold board where specifications require flat bottom ditch. All back sloping done with mold board, doing away with cumbersome and inefficient back sloper attachments.

Models: Made in three sizes, with 10-ft., 12-ft. and 14-ft. blades. All models have leaning wheels, front and rear, equipped with Timken roller bearings.

General Specifications

All adjustments motor controlled.
Leanable frame.
Leanable wheels.
Reversible mold board.
Alemite oiling system.
Timken tapered roller bearings.
Manganese steel castings.
S. A. E. gear specifications.
Bronze bearings and thrust washers.
Bronze lift gear wheels.
Fabricated trussed frame.
Roller bearing circle.

THE BAKER MANUFACTURING CO.

516 Stanford Ave., Springfield, Illinois

Manufacturers of Earth Moving Specialties and Snow Plows

Distributors in all principal cities

Products: Self-Loading Scrapers, Snow Plows, Backfillers and Road Maintainers.

BAKER

Baker-Maney Self-Loading Scrapers: Baker-Maney Self-Loading Scrapers are built for heavy tractor use singly or in trains of from two to six scrapers. They are made in two sizes—Model "D" 1¼ cu. yd. capacity and Model "H" ¾ yd. capacity. One man, besides tractor operator, will handle up to four scrapers. Two men will handle any length train.

Model "D" 1¼ yd. Baker-Maney Scraper

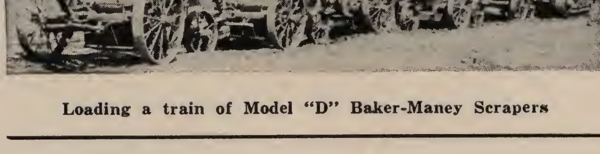
Model "D" 1¼ yd.—Axles, 2½ in. sq., Wheels, front diam. 30 in. Rear 46 in., all 6 in. tires. Weight 4200 lbs.
Model "H"—¾ yd.—Axles 2 in. sq. Wheels, front diam. 24 in. Read 42 in. All 6 in. tires. Weight 2700 lbs.

Loading and Dumping: Loading is done one scraper at a time, operator passing from one scraper to another, loading usually at the rate of 10 seconds per scraper. Automatic tripping device causes pan to lock when reaching carrying position. Instant dumping is accomplished from the rear by pulling a chain. On ordinary clay soils with a good tractor no plowing is necessary.

Trailing: Full trains turn in a space less than 20 feet without binding or overturning. They are built especially strong for travel over roughest ground and with the heaviest tractors made.

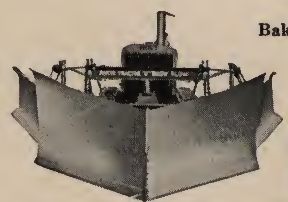
Power Required: Tractors developing 25 to 30 H.P. at the draw bar should load and haul three to four Model "D" Scrapers. Tractors of 40 H.P. at draw bar should handle four to six scrapers. Model "H" ¾ yard scrapers can be handled in trains of two to four scrapers by tractors up to 30 H.P. at the draw bar.

Yardage: The yardage on a 500 foot haul with 4 Model "D" Scrapers under average conditions should reach 500 yards in a 10 hour day. With a similar train of Model "H" Scrapers it should reach 360 yards.

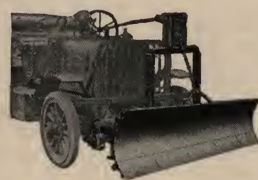


Loading a train of Model "D" Baker-Maney Scrapers

Some Types of Baker Snow Plows



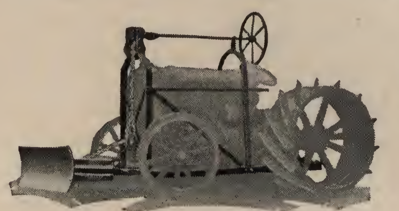
Baker Tractor "V" Snow Plow



Baker Auto Truck Snow Plow

Baker "V" Truck Snow Plow

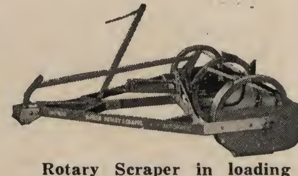
Baker Snow Plows For Motor Trucks and Tractors: Baker Snow Plows are made for attachment to any standard motor truck or leading industrial tractor in both "V" and blade types. Straight blade Snow Plows are equipped with Baker Patent Sectional Tripping Blades which protect plow when striking unseen obstructions on the pavement. "V" plows for motor trucks are made with or without wings to cut a path from 9 to 15 feet wide. Auto Truck (Blade) Snow Plows are made with 8 and 10 foot blades. We make Speed Plows for trucks, both "V" and blade types. The larger tractor plows are equipped with hydraulic lift.



Baker Backfillers are used for refilling trenches, pushing dirt over banks, leveling rubbish piles and wherever material is pushed ahead.

Baker Backfillers: Baker Backfillers or Bulldozers are made for attachment to leading makes of industrial tractors. Special frames are made for the tractor used, attaching without drilling holes. All blades are made for long wear, with replaceable cutting edges of high carbon steel.

Baker One-Man Rotary Scrapers: Baker Rotary Scrapers are one-man scrapers for use behind any tractor. One lever controls all operations. No stopping for loading or dumping. No backing up to dump. Made in the following sizes:



Rotary Scraper in loading position

No. 4—4 ft. wide	Weight— 600 lbs.
No. 5—5 ft. wide	Weight— 660 lbs.
No. 6—6 ft. wide	Weight— 990 lbs.
No. 7—7 ft. wide	Weight—1,065 lbs.

THE RODERICK LEAN COMPANY

Mansfield, Ohio

Manufacturers of "Groundhog" Revolving Tractor Scrapers

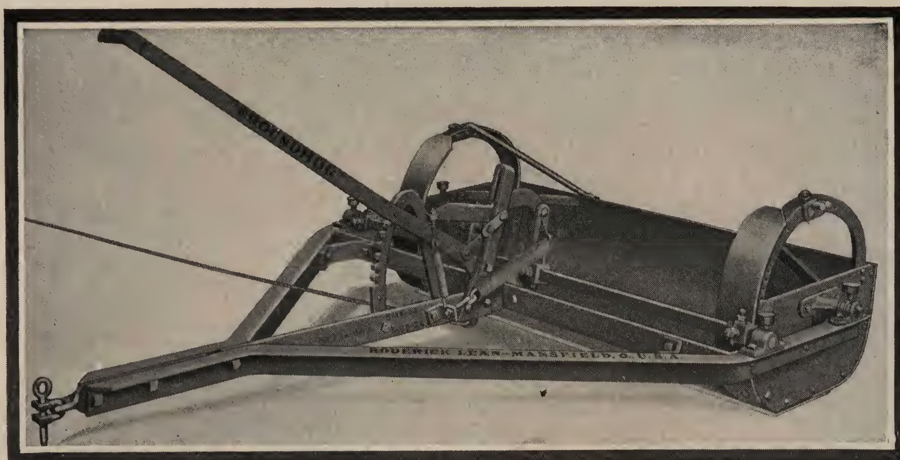
Products: "GROUNDHOG" REVOLVING TRACTOR SCRAPERS.

Specifications:

No.	Width of cut	Capacity	Weight
4A	4 ft.	3/5 yd.	501 lbs.
5A	5 ft.	3/4 yd.	552 lbs.

Power Requirements: Suitable for use with Fordson, Cletrac model "K," Caterpillar 2-Ton, McCormick-Deering, Twin City, and all other standard tractors of similar plowing ratings.

Kinds of Work Used for: Road work, street grading, excavating, leveling allotments, golf course construction, airport, park and cemetery grading, and every job where dirt must be moved or leveled.



The "Groundhog" in loading position

Long Loading Lever Gives Positive Control of Loading: With the "Groundhog" Scraper, loading is controlled by the single long lever which is always within easy reach of the operator. To load, it is only necessary to raise the lever, the position of the lever determining the depth of cut. By raising the lever only part way a very light cut for finishing work may be taken, or by raising to the full height a very heavy cut which will load the scraper within a few feet, will result. Loading is stopped instantly by shoving the lever down.

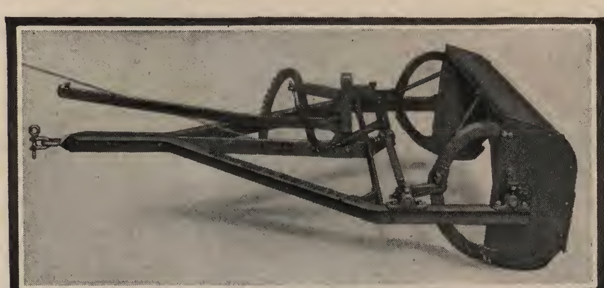
When the lever is in the bottom notch of the ratchet, the bowl is raised enough so that the load may be carried over a pile of soft earth without cutting down the pile. With the lever in the second notch the blade is raised enough to stop loading, but not enough to lose the load regardless of the distance it is to be carried.

Spreads or Dumps on a Pile by Simply Pulling a Rope: When ready to spread, a light pull on the trip rope permits the scraper to revolve to spreading position. The position of the pins on the revolving frames regulate depth of spread.

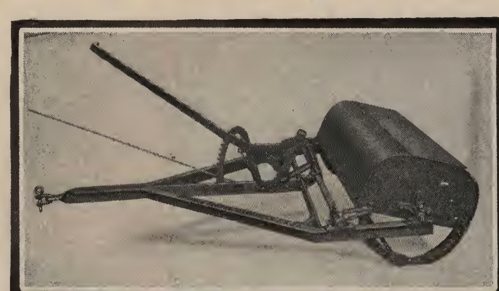
If desired to dump the load in one place, it is only necessary to pull and hold the rope forward until the bowl revolves to dumping position. In work such as filling in, or in irrigation work, where it is always desired to dump the load in one place, the spreading pins may be removed entirely; under these conditions only one pull on the trip rope is necessary to permit the scraper to make a complete revolution and come back automatically to loading position.

Revolves Backward: The "Groundhog" revolves backward as well as forward. This feature is a big advantage in excavation work, as the scraper can be backed into the corners and when started forward starts loading immediately.

Spreading the load. Another jerk on the trip rope and the bowl will revolve to loading position



Spreading position



Dumping position

THE GUSTAV SCHAEFER WAGON COMPANY

4180 Lorain Ave., Cleveland, O., U. S. A.

Automatic Tractor Scrapers

Products: AUTOMATIC TRACTOR SCRAPER. Automatic (one-man) Tractor Scraper. On the market since 1921; simple, safe, strong. A practical earth-moving tool; especially good for short hauls.

Schaefer
CLEVELAND

Full control from seat while tractor is in motion. Nothing to oil or adjust.

Models 264 and 265 (for light tractors such as Fordson, International, Cletrac, etc.) have the new style hitch which is made principally of Certified Malleable Iron. The Model 264 is a good tool for beginners and for those who are obliged to operate under very severe conditions. The Model 265 is the most popular size and can be used successfully on a great variety of jobs. The No. 6 and No. 7 sizes have heavy wrought iron hitches. These latter sizes are intended only for larger tractors. See next page about new "Auxiliary Back-Up Control" now available for Models 264 and 265.

A practical earth moving tool.
Four Stock Sizes
(Capacity varies with soil conditions)

Scraper Model	Scraper Width	Approximate Capacity	Shipping Weight, Complete
264	4 ft.	13 cu. ft.	400 lbs.
265	5 ft.	16 cu. ft.	430 lbs.
No. 6	6 ft.	20 cu. ft.	610 lbs.
No. 7	7 ft.	25 cu. ft.	650 lbs.
Auxiliary Back-Up Control			75 lbs.

Safe to Use because all the working parts are back of the driver, who controls the various operations, Loading, Dumping, Spreading and Leveling directly from the seat while the tractor is in motion. (Pulling a regular horse-drawn slip scraper back of a tractor has been found a dangerous practice, and besides it requires two men where the automatic needs but one.)

Strong Construction improved over a period of years. The bowl has a broad upper flange and is held rigid by two double-action braces. The blade and the reversible shoes are made of high carbon knife steel. Malleables on Models 264 and 265 have grooves for the braces. The heads of the SAE bolts are set into sockets so that the drop forged wrench which is furnished with these models is all that's needed to install a new part.

List of Work Done to Good Advantage with Schaefer Scrapers (throughout the world since 1921) includes Laying out Allotments, Roads, Parks, Cemeteries; Ball, Golf and Aeroplane Fields; Digging Cellars and Ponds, Leveling Hills and Beaches, Grading around new schools, Filling trenches. Also in Brickyards, Potteries, Fisheries, etc.

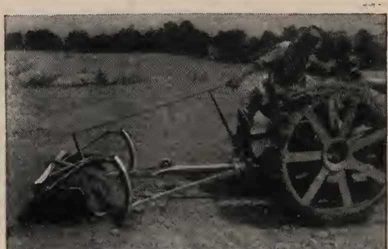


Fig. 1.—Loading

Fig. 2.—Hauling

Simple Design is such that almost any one with ordinary skill can move earth successfully. Wear-parts are few and easy to replace.

Economy of Operation is due to the great power, speed and steady performance of tractors and the fact that only one man is needed to operate the unit. Workmen like this Scraper because it lets the tractor do the heavy work and because its simple design makes it so easy to operate. Contractors recognize it as a time-tried tool of proven worth. A piece of equipment which earns its cost in a short time.

Fig. 3.—Dumping and Spreading

Fig. 4.—Returning for Load

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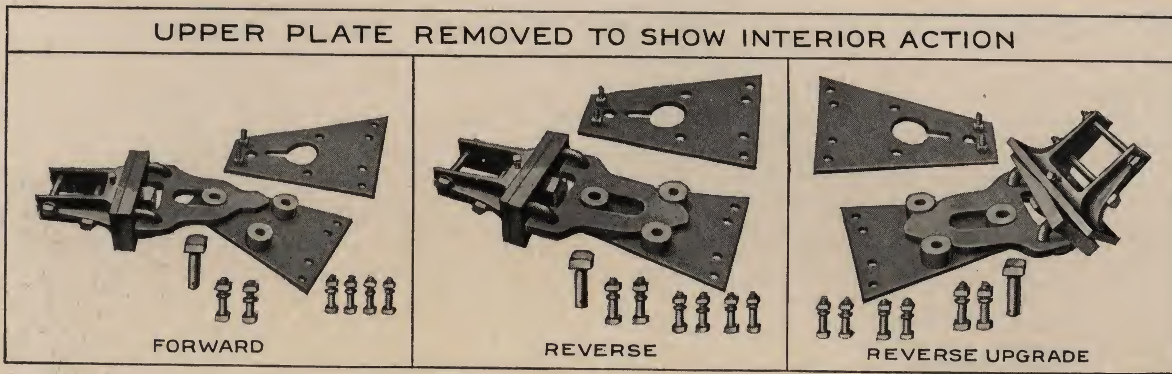
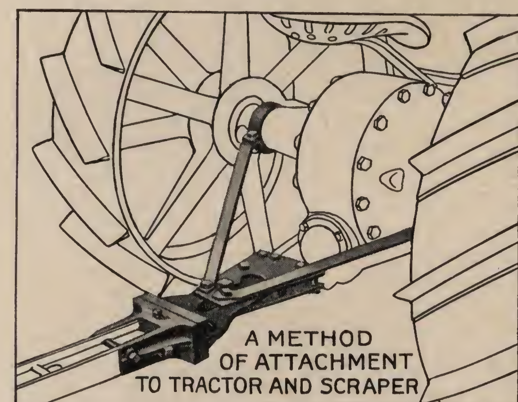
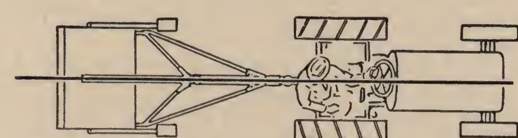


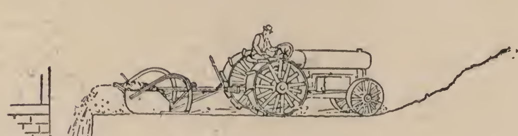
An Auxiliary "Back-Up" Control (patents applied for) for the Schaefer Automatic One-Man Tractor Scraper. The Models 264 and 265 Schaefer Automatic Tractor Scrapers can be supplied with an "Auxiliary Back-Up Control." This lock requires no operating levers nor adjustments. It provides universal action in the forward position (does everything which the regular equipment can do) and when the tractor is backed up, the Scraper is automatically locked so that it cannot buckle sidewise, but must remain in line with the tractor. The lock does not interfere with the up and down movement of the Scraper nor with the swivel action.





KEEPS TRACTOR AND SCRAPER IN LINE

DOES NOT INTERFERE WITH UP OR DOWN MOVEMENT AND SWIVEL ACTION



BACK FILLING

While ordinary work does not require the "Auxiliary Back-Up Control" it adds to the usefulness of the Scraper, especially in crowded places and in getting in around trees, obstructions, etc., because when it is used, the tractor does not have to make loops or turns to get the Scraper into the desired position. The Scraper may be operated backward and forward in shuttle fashion, which saves time, especially on cellar excavations, back-filling, etc.

Caution: When ordering the "Back-Up Control" always state make and model of Tractor used, also type of fenders and crawler tracks (if any) so that proper braces can be supplied with the unit.

Note: When operator does plowing, he may disconnect the lock and insert a half-inch chain through the slot in the upper plate. The "Back-Up Control" parts are painted green in order to distinguish them from the "Schaefer Scraper Hitch," which is painted red.

The Schaefer Trade Mark is the buyer's assurance that he is getting the best product of an organization which for nearly half a century has maintained a high reputation for quality in Custom-Built Truck Bodies, Special Trailers, Wagons, Loading Machinery, etc. The same degree of care that has built up the standing of these lines has been exercised in developing the Schaefer Scraper.

Succeed with Successful Tools

Earth Road Grading and Maintenance Methods

EARTH ROAD BUILDING WITH BLADE GRADER.—*Roads and Streets* gives the following: An important factor in Iowa road construction and maintenance is the methods employed by the blade and grade operator in burying the sod.

Sod in the middle of a road, usually found now only on the township road system, was in the early automobile days, a regular bugbear to traffic on main Iowa highways. A crew with horse-drawn outfit or a tractor and blade grader would work its way down the highway, tearing up mile after mile of fairly good trail, heaving sod and rubbish into the middle of the right of way and leaving it there untouched. Many times roads of this character would be impassable for months for cars and even extremely difficult for team traffic.

This practice went on for years in Iowa; until, in fact, during the season of 1914. During this season, in several counties, blade grader operators, who put brains into their work as well as muscle, started at about the same time, practicing a system of throwing a thin cut of sod and dirt from the shoulder and side ditches to the center of the road on the first trip, distributing it there evenly. Later, it was covered with clean earth from the side ditch and shoulders. This left a clean roadway with no sod or rubbish to interfere with finishing and subsequent maintenance. Stories and photographs of work done in these counties spread the information over Iowa and the sod in the middle of the road rapidly began to disappear from the main highways, or, as they were then classified, "county roads."

This method worked satisfactorily in building up the road grade and crown for the first time. The sod and grass spread out evenly over the flat road, was easily buried under the material which was later thrown up to build the crown. However, in the past few years, when it became necessary to reshape a road, which already had a fairly good crown, it was found impossible to throw the grass and sod again upon the crown and successfully cover it up. Not enough new material was needed in reshaping the crown to cover the sod. Some new method of disposing of the sod and weeds from the shoulder and side ditch had to be devised.

The New System of Burying the Sod.—During the past two or three years a blade grader expert in the employ of the commission, Mr. O. M. Briley, has been working out a new system of burying the sod which has been giving splendid results. The first extensive tryout was made in Clinton County, though it was previously used in maintenance work on the state road about Iowa State College.

Mr. Briley describes the method as follows:

"No one general rule or method of procedure will apply to all roads and all conditions. Generally I find that one plan which I will describe, works satisfactorily in most cases where the crew goes out to rebuild or reshape an old road which has been previously put to permanent grade. The same system should apply to reshaping most of the roads which have been previously put to standard cross section only by the blade grader.

"We find the stakes set by the engineers, usually in the bottom of the side ditch or where the side ditch is to be. I measure the width apart of the front grader wheels and then set a new line of stakes or move the old ones just the width of the grader wheels inside the first line up onto the shoulder of the road. With my stakes well up on the shoulder of the road I have a good, clear line to follow in making my first cut and usually a good footing for both the engine and grader. I find this is a great help in making a good looking, straight shoulder line for my road grade.

"On the first cut I set the outer edge of the blade as high as possible, sending the cutting point down so that it will gouge out a rather deep and narrow furrow. As I go I take out my entire new line of shoulder stakes. Material thrown out of this furrow frequently carries with it considerable grass and rubbish but seldom heavy sod. This, of course, goes toward the center of the road into more or less of a ridge, but usually there is no difficulty in covering the material up in later operations. On my next trip around, the deep furrow forms a trench to guide and hold my left front wheel for the first heavy cut which usually gives me the shoulder line of the grade and the center line for the bottom of my side ditch. The furrow also provides the trench in which to throw the sod and grass that comes out on this second round.

"Usually one cut gives the lineup for my side ditch and shoulder and gets most of the grass and sod up into the trench. As this material comes off the blade it is usually turned sod side down into the bottom of the trench and left with a thin coating of fairly clean earth on top. I then make as many cuts as are necessary to open the side ditch properly, clean off the back slope and get the material needed to fill out and shape up the road grade in the customary manner. All this latter dirt is, of course, thrown on top of the sod and provides good, clean earth for finishing and working up the traffic surface.

Occasionally when the traffic surface is badly weed grown a considerable distance out from the shoulders making too much grass and sod to throw toward the center when making the first trench cut described above, I make a thin cut on the first trip around, throwing the skimmed off sod and weeds out into the side ditch. The next trip around the trench is made and on the third trip, or the first trip made down the side ditch, the skimmed off sod and grass with additional material is thrown back on top of the road and into the trench. The building and shaping of the road grade is then continued as described above."

BLADE GRADER WORK IN IOWA.—Mr. W. H. Root, Maintenance Engineer, Iowa State Highway Commission, gives the following in *Roads and Streets:*

On Jan. 1, 1923, the primary roads of Iowa were classified as follows:

	Miles
Paving	334.4
Gravel	1,558.0
Graded and drained	1,761.1
Not built	2,961.8
Total	6,615.3

In other words, out of 6,615 miles of primary road, 4,723 miles or 71 per cent of the whole system, are unsurfaced. The Iowa Highway Commission has chosen to look upon its primary road sytem as the backbone of a state-wide transportation system. They believe that the public is entitled to a usable system of roads whether such roads have been constructed or not. As a result of this policy the maintenance forces of the state are required to maintain the whole 6,615 miles of road, 45 per cent of which has not even been built to an established grade line, and of which 71 per cent is ordinary earth road. These figures show, I believe, that the Iowa maintenance problem is an earth road

problem and they explain why we have concentrated on earth road maintenance.

Classes of Blade Grader Work.—I think that I can state without the least reservation that the most useful and indispensable tool for earth roads is the heavy blade grader. By this I mean a grader with a blade length of from 12 ft. to 16 ft., built heavy enough to do work that will require 30 to 50 drawbar horsepower. A blade grader of this sort is adapted to various kinds of work. The three main classes of blade work are:

1. Heavy blade work on roads which have never been built; that is, widening out and building to standard cross-section trails which have never really merited the name "road."
2. Finishing work on new construction.
3. Surface smoothing operations supplementary to regular patrol work.

How Blade Grader Work Is Carried On.—It was in 1913, I believe, that the first 12-ft. blade machine was shipped into the state of Iowa. Now there are at least 400 of these machines in the state. In our early blade grader work we erred in not doing a thorough enough job. We paid little attention to getting the fences back to the line and clearing the right of way. We merely shaped up the road as we found it. From 5 to 10 round trips were made and the total cost per mile was only \$50 to \$75. Each year, however, we have attempted to do more work and get a better road. We now require the fences and telephone poles to be moved back to the highway line before we start work. All trees, stumps and boulders are then cleared from the right of way. This work alone in some parts of the state runs as high as \$200 to \$300 per mile. All heavy weed growths are also cut and raked up and burned. After the right of way has thus been cleared we are ready to start the blade work proper. The ditch line is staked out (18 ft. each side of the center line) with lath. Enough lath are used so that two laths are always visible to the grader operator.

Each mile of road is a problem in itself. An ingenious grader operator will save lots of time and money by cutting down the number of round trips necessary. High side banks, narrow fills off center, and wet ditches are only a few of the things that make a first class blade grader job difficult and expensive. We much prefer a blade grader with a back sloper attachment, that is, an attachment which may be bolted on the end of the blade so that the ditch bottom and back slope may be cut at the same time as the inside slope. A properly designed back sloper will cut the standard ditch and back slope when the main blade is cutting the standard inside slope. The back sloper should be adjustable so that the back slope can be flattened from 1½ to 1, to 2 or 2½ to 1 where extra dirt is needed.

Cost of Blade Grader Work.—On an average road we now make from 10 to 15 round trips with a single grader. Some counties still pull two 12-ft. graders with one tractor but I do not believe that this is economical. Where this practice prevails one grader of necessity must lie idle much of the time and the turning is more difficult. The average cost of our blade work, including clearing, is about \$150 per mile. However, we often have miles which run as high as \$500 or \$600 per mile. You would be surprised at the extensive work which is accomplished by some counties with the 12-ft. blade. We have built side hill roads in hilly counties where the material was mostly loose rock, and have had excellent results. Work of this sort when finished looks much more like permanent grading than it does like blade grader work.

No two miles of road require the same treatment, and the cost of blading, therefore, varies greatly. The following figures, however, roughly represent the cost of the average mile:

	Per mile
1 tractor operator, 25 hrs., at 75 cts.	\$ 18.75
1 grader operator, 25 hrs., at 60 cts.	15.00
125 gal. of gas at 22 cts.	27.50
Oil and grease	3.00
Depreciation on a \$6,000 investment figuring a 3 year life of 100 working days per year—2½ days at \$20 per day	50.00
Estimated repair, 2½ days, at \$5	12.50
Interest on investment, (5% on \$3,000), 2½ days, at \$1.50	3.75
Clearing right-of-way and incidentals	19.50
Total	\$150.00

Finishing Work on New Construction.—The second class of a blade grader work as outlined above is the finishing of permanent grading. By permanent grading, I mean building a road to an established grade line which is presumably a permanent one. In grading operations in Iowa most of the dirt is moved with elevating graders and dump wagons. We insist on a Mormon scraper being kept constantly at work on the dump but the best job that can be done in this way is necessarily rough. Therefore, we require every grading contractor to have a 12-ft. blade grader in his equipment. This grader is pulled by a large engine and the road finished smooth close behind the rough grading. Often the same tractor that pulls the elevator is used evenings and at odd times to smooth up the work.

We also find that all new grading settles unequally after a few rains. The shoulders usually become low and ragged, the ditches start to fill, and the back slopes sluff. It then becomes necessary to again blade the job. This last blading is done by the county as a maintenance measure. The back sloper is used. It fits into the ditch and back slope and builds the shoulder up in a uniform manner. The result is a workmanlike job, without perceptible waves, and the cost is only \$50 or \$75 per mile.

Surface Smoothing Operations with Blade Grader.—The slogan of the National Paint Manufacturing Association, "Save the surface and you save all," might be studied to advantage by state maintenance departments. The public judges a road by its surface. A road is good or bad, as it is smooth and comfortable to ride over at 35 miles an hour, or as it is rough and inconvenient to travel at that speed. The user of the road cares little for clean ditches and nicely lined shoulders, if the surface is rough. This suggests the third and most appreciated class of heavy blade work. We have the patrol system of maintenance in our state but on practically all earth roads on the primary system we find supplementary maintenance with a heavy machine very necessary. For this work we again prefer the heavy 12-ft. blade grader. In a number of cases we have lengthened these blades to 16 ft. or 18 ft. in order to cover the road surface in one round trip. Often we are able to pick up old graders which have become worn and loose jointed. These old machines can be bought for a song. We equip them with extension blades, put on heavy springs between the frame and the blade, to take up the play, and thus obtain an ideal maintenance machine.

This most difficult maintenance problem that we have is presented by a heavy soil road with heavy traffic, say a dense yellow clay road carrying 1,000 vehicles a day in all kinds of weather. It is obvious that before such a road has a chance to dry out so that it can be dragged, it has been hammered down until it is about as hard as a concrete pavement. However, the riding qualities are not at all similar to those of a concrete pavement. It is rough and rutted and anything but a pleasure to travel over. It is also absolutely beyond the control of any light equipped patrolman. Nothing but a heavy blade will ever put such a road back in sat-

isfactory shape for travel. This, I believe, covers the field of the heavy blade grader.

Use of Road Drags.—The road drag is also a widely used tool in our state but its work is not so readily classified. We have almost as many different kinds of drags and maintainers as we have operators. We have everything from a 2-bladed drags weighing around 200 lb. and easily pulled by 2 horses, to big heavy maintainers weighing 1 ton or more and pulled by 20 or 25-h. p. tractor. I do not expect to enter into a discussion concerning the relative value of these different machines, suffice to say that they most all have their good points. In my opinion the man, not the machine, is the important factor. I would rather have a live, ingenious man with good road sense equipped with an old fashioned split-log King drag than a "dumb-bell" with the fanciest maintainer manufactured.

We divide our earth roads into patrol sections of about 10 miles each. A patrolman is placed in complete charge of each section and he is held responsible for its care. He is usually equipped with a patrol grader, a drag, a slip scraper, a plow, and a set of small tools. He also has access to other equipment such as the wheel scrapers, mowers, etc. He furnishes one team all of the time and in most cases has a second team which can be procured when needed. On the heavy soils we have to use four horses even on a small patrol grader. The patrolman's first duty is to keep the surface of the road smooth. To do this he must drag or see that the dragging is done on his entire section as soon as possible after each rain. On light soils the dragging can be started after a few hours of sunshine following a rain and the equipment may be either a light patrol grader or a drag. A patrolman on this class of soil can care for his section with not to exceed one extra dragger. On heavy soils it takes much longer for the road to dry out sufficient to drag. Here the first dragging may be done by the patrolman but he will need 3 or 4 extra draggers. Often on this class of work the first dragging is done with heavy equipment.

In no case is one dragging enough. Lighter soils must be bladed with the patrol graders a second or third time until the surface is smooth. The first dragging on the heavy soils only partially breaks up the clods and incompletely fills the ruts. It must be immediately followed by a second or a third smoothing with heavy equipment. As stated before, we prefer a 12-ft. or 16-ft. heavy blade for this final polish.

We have also used in our dragging a large number of the surplus war trucks which we received from the federal government. A separate maintainer is sometimes pulled behind the truck but we have had the best results with a maintainer built around the truck.

The Iowa earth road policies might be briefly summarized as follows:

1. Realizing that we will have to depend upon earth roads on a large part of our primary system for a number of years to come, we believe that we are justified in an intensive maintenance program on these roads in order to give the traveling public service while they wait for our constructon program to eliminate the mud.

2. As a first step in this program we have graded with the heavy blade grader practically every mile of primary road that has not been otherwise constructed.

3. For finishing grading which has been built with an elevating grader and dump wagon, the 12-ft. blade grader is a most useful tool.

4, The heavy blade is indispensable for surface smoothing, especially on heavy soils.

5. Earth roads should be patroled and the patrol sections should not be over 10 miles in length.

6. All patrol and light drag work must be supplemented with heavy maintenance machines.

Our maintenance ideal is continuous, automatic care and definite, individual responsibility.

Cost of Small Steam Shovel Work in Road Grading, California.—J. E. Bonersmith gave the following in *Engineering and Contracting:*

The work described was on the California State Highway between Tormey and Eckley in Contra Costa County, California. The road graded was four miles in length and contained 72,000 cu. yd. of excavation through a rather rough country. The material consisted of earth, soft and hard shale.

The method of work was as follows: After the culverts were constructed two fresno gangs (each gang having a six-horse plow and from four to six fresnos) were started and made the fill over the culverts; also moved the dirt in all cuts where the hauls were 200 ft and less. A revolving shovel followed the fresno gangs and loaded all the material that had to be hauled into dump wagons. The number of wagons varied from six to twelve. Behind the steam shovel, a small fresno with four muckers did all the finishing work.

The road was graded to a width of 21 ft. and through the cuts the shovel had to turn through a full 180°. On this work, the average output of the shovel for an 8-hour day was 375 cu. yd., as there was considerable loss of time in spotting the wagons; but where the shovel was only going through 90°, it handled 510 cu. yd. The local water was the cause of some delay and since the water is a very serious question in the cost of equipment on any job, we now make it a rule to have the water analyzed and the proper boiler compound on hand before the shovel starts to work.

Costs to job in day rentals: Horses rented to job at $2.25 per working day; fresnos, wagons, etc., at $0.50 per working day; wagon and fresno drivers at $4.00 per day; steam shovel, including fuel, runner, etc., $75 per day. These costs of equipment are used on all our work as we have found from many years of experience that it is the only way we can arrive at a true cost. Take the shovel as an example; its rental is based on the following charges:

First cost, $10,000; life of shovel, 1,000 working days in six years; cost per day	$10.00
6 per cent interest on $10,000 for three years, $1,800; interest per day	1.80
Repairs (when the shovel is broken down the runner's, firemen, etc., time is charged to repairs), per day	4.00
Freight, knocking down, etc. (this cost was arrived at by cost kept on another shovel), per day	6.00
Fuel, ¾ ton of coal per working day at $12 per ton	9.00
Water wagon with four horses and driver, per day	13.00
Water and oil, per day	1.70
Runner per day	10.00
Fireman, per day	5.00
Two pit men at $4.00 per day	8.00
Incidentals	5.84
Total cost per day	$74.34

Following is the total cost of the above mentioned grading of the State Highway between Tormey and Eckley:

Horses, 8,756 days at $2.25 per day	$21,890.00
Equipment, 1,842 days at 50 ct. per day	921.00
Driver labor, 1,842 days at $4.00 per day	7,368.00
Steam shovel, 104 days at $75 per day	7,800.00
Foreman, 120 days at $9 per day	1,080.00
Timekeeper, 4 months at $150 per month	600.00
Muckers and slopers, 500 days at $4 per day	2,000.00
Muckers, slopers, etc., 212 days at $4.50 per day	954.00
Purchases (picks, shovels, lanterns, oils, etc.)	365.20
Insurance	400.00
Total cost	$43,378.20
Cost per cu. yd.	$ 0.6025

Costs on Street Grading with a Steam Shovel, in Minneapolis, Minn.—Fred T. Paul gave the following data in *Engineering and Contracting:*

The work under consideration was done by force account under the City Engineer's Department, W. J. Walsh, acting engineer in charge. The material moved was a conglomerate with a medium fine sand predominating. The cut was from 2 to 15 ft. deep, 70 to 80 ft. wide, and about 3,500 ft. long. A ¾-cu. yd. traction steam shovel placed the material in ordinary 1½ cu. yd. dump wagons, and these in turn deposited it in the fills on the street, making an average haul for the job of 1,000 ft.

The work was started June 12 and finished on Aug. 20, covering a period of 55 full working days of eight hours each, and five part days. On these part days, little, if any, dirt was moved, but the engineer, foreman, fireman, watchman and timekeeper received full time—while the laborers and teams were given only part time. A total of 21,500 cu. yd. of material was handled in the 55 full days, making an average day's output of 391 cu. yd. The maximum was reached during five days in the heaviest cut when 611 cu. yd. per day was moved.

The total material cost of the job was $378.85, distributed as follows:

27.45 tons of soft coal at $10 per ton	$ 274.50
50 gal. steam cylinder oil at $0.294 per gal	14.70
Blacksmith repairs	34.00
New shovel parts	1.65
Miscellaneous, including waste, packing hose, grease, etc	54.00
	$ 378.85

The average daily pay roll was as follows:

1 foreman at $8 per day	$ 8.00
1 runner at $12 per day	12.00
1 fireman at $6 per day	6.00
1-20th timekeeper at $7 per day	.35
1 watchman at $5 per day	5.00
2 laborers on dump at $5 per day each	10.00
2 laborers in pit at $5.50 per day each	11 00
1 laborer on coal and water at $5 per day	5.00
6 laborers straightening and leveling up at $5 per day each	30.00
7 teams on dump wagons at $9 per day each	63.00
Total average daily payroll	$ 150 35
Grand total payroll for sixty days	9,021.00
Total material as above	378.85
Interest and depreciation on plant	140.00
	$9,539.85

Distribution and Unit Costs

General—	Amount	Per cu yd.
Foreman, 60 days at $8	$ 480.00	$0.02232
1-20th timekeeper, 60 days at 35 cts	21.00	.00098
Total general	$ 501.00	$0.02330

Excavating and Placing Material in Wagons

Labor—		
Runner, 60 days at $12	$ 720.00	$0.03349
Fireman, 60 days at $6	360.00	.01675
Watchman, 60 days at $5	300.00	.01395
2 pit laborers 58 days at $11	638.00	.02968
Laborer on coal and water, 58¼ days at $5	291.25	.01355
6 laborers on cleanup, 58 days at $30	1,740.00	.08093
Total labor	$4,049.25	$0.18835
Material and supplies as above	378.85	.01664
Interest and depreciation on plant, 10½ per cent on $9,000 for 60 days	157.50	.00692
	$4,585.60	$0.21191

Hauling, Including Placing in Dump

7 teams, 58½ days at $63	$3,685.50	$0.16183
2 laborers, 58 days at $10	580.00	.02547
	$4,265.50	$0.18730
Grand totals	$9,352.10	$0.41068

Based on the total cost of moving 21,500 cu. yd. an average distance of 1,000 ft., the cost per cubic yard hauled 100 ft. would be $0.0411. However, the actual hauling cost per cubic yard per 100 ft. was only $0.0201.

Steam Shovel Excavation in Shallow Cut for Road.—*Engineering and Contracting* gave the following:

A road grading cut 1.6 miles long and nowhere exceeding 18 in. in depth was made in 54 days for a brick on concrete base pavement on Ocean Ave., Deal, N. J. The total amount of excavation was 30,000 cu. yd. The shovel had a ⅝ cu. yd. dipper, and during the time it excavated 17,704 cu. yd. Working a 10-hour day, the greatest yardage was 477 cu. yd.; the average yardage, excluding lost time, was 33 cu. yd. per hour. During the 54 working days 25½ hours were lost, due to rain or other causes. Some partial records were as follows: In 9 days two blocks 700 ft. long and 50 ft. wide were cleaned up. Again, in one week, in a cut running from 9 to 18 in. deep, an advance of 200 ft. per day was registered, or an average of about 350 cu. yd. per day. The haul averaged about a half mile. The shovel had to wait for wagons at times from two to three minutes.

Oiling Dirt Roads in Jackson County, Missouri.—Mr. Leo E. Koehler gives the following in *Roads and Streets:*

Our idea of the proper shaping of a dirt road for the receiving of oil is as follows:

The road must be thoroughly ditched and all loose material removed from the roadway to be oiled. Always grade the roadway from the center, pushing the loose material to the outside quarters; here is where a good blade machine man is to be appreciated, as a poor man can do more damage with a blade in one day than can be corrected in several days. The surface of the road should be as solid and free from loose earth as it is possible to make it and should be crowned only enough to cause the water to flow to the ditches, and in this connection will say that it is much better have the road too flat than over-crowned, as on a flat surface the travel is more evenly distributed over the entire surface, thereby causing longer life to the road and more safety to travel. Most roads in this section have a longitudinal grade which will take care of the drainage with a very slight crown. A draw always working from the center towards the side of the road should be used after grading is finished.

It is very essential that oil for dirt roads should be as near non-volatile as possible, should contain not less than 60 to 70 per cent asphalt and as great a percentage of saturation as possible. The method of refining has much to do with the saturation, volatilization and quality; therefore, we deem it highly essential that a chemical analysis of the oil to be used be made before it is applied.

The oil may be applied by either the pressure or gravity feed system. We have adopted the latter on dirt roads on account of the excessive weight of the former, as we found that many of our small bridges and culverts would not carry the weight.

The oiling of hard surfaced roads, we believe, can be done much better by the use of the pressure system as it sprays the oil on much more evenly than can be done by gravity, but on dirt road this is not essential.

J. D. ADAMS & COMPANY

Indianapolis, Indiana

Adams Adjustable Leaning Wheel Graders, Road Machinery and Tools

Branches: Minneapolis, Kansas City, Dallas, Memphis, Harrisburg, Pa., Spokane, Regina, Toronto

Products: Adams Leaning Wheel Graders in Various Sizes, Scarifier-Graders, Grader Blades for any make of Grader, Road Maintainers, Road Drags, Road Patrols, Elevating Graders, Dump Wagons, Wheeled Scrapers, Drag Scrapers, Fresnos, Road Plows and Rooter Plows.

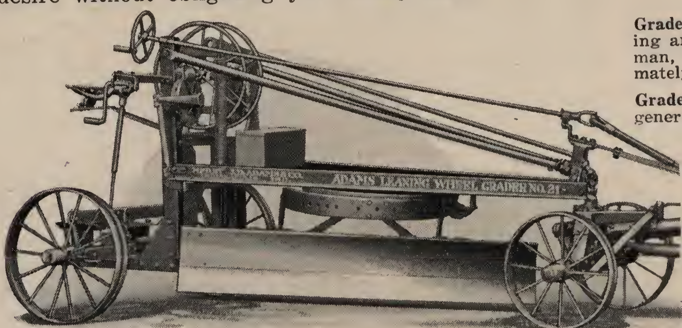
Sales Service: Adams equipment is represented in every state and province of the United States and Canada and most foreign countries either by direct factory representatives or by distributors. A request addressed to Indianapolis or any of the branch offices listed above will place an Adams representative at your service to furnish prices and such information as you desire without obligating you in any way.

TRADE MARK
Reg. U. S. Pat. Office.

Adams Leaning Wheel Graders Made in Eight Sizes: Adams are the original leaning wheel graders which have been a proved success since 1885. There is a size for every power from two horses to the largest tractor, as shown below.

Outstanding features, in addition to the adjustable leaning wheels, are machine-cut and enclosed lift gears on all models, machine finished bearings and ball and socket joints throughout the blade control, equalizing lift springs, trouble-proof steerable engine tongues, spring platforms, the patented Adams "One-Piece" Rear Axle, well balanced design, high quality materials and workmanship, and long life. Furnished as follows:

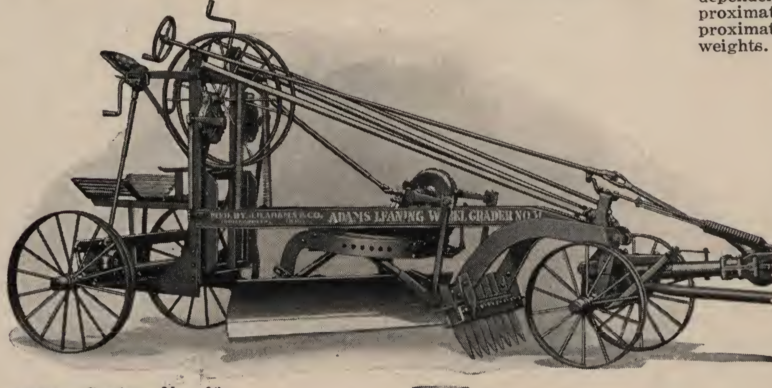
Grader No. 1-C: Furnished with 6½ or 8 foot blade for light ditching and maintenance. Used as one-man, two-horse machine or two-man, four-horse machine. Weight with two horse hitch, approximately 1,525 lbs.



Grader No. 21: With 7 foot blade; see illustration to left. A general utility machine for use with four or six horses or with tractors and trucks of 8 to 12 drawbar H. P. Weight with four horse equipment 2,085 lbs., with six horse equipment 2,105 lbs., and steerable engine tongue 2,285 lbs.

Grader No. 7: Has 7 foot blade; an all purpose machine for use with six horses or tractors of 10 to 18 drawbar H. P. Strong and heavy enough for all moderate grading and yet light enough for general maintenance work. Weight with six horse equipment 3,600 lbs.; with steerable engine tongue 3,900 lbs.

Grader No. 31: With 7 foot blade—illustrated to left. Used with six horses or tractors of 10 to 15 drawbar H. P. Is furnished with or without scarifier, which is controlled independently of the blade. Weight with six horse hitch approximately 2,535 lbs.; with steerable engine tongue approximately 2,660 lbs. With scarifier add 690 lbs. to above weights.



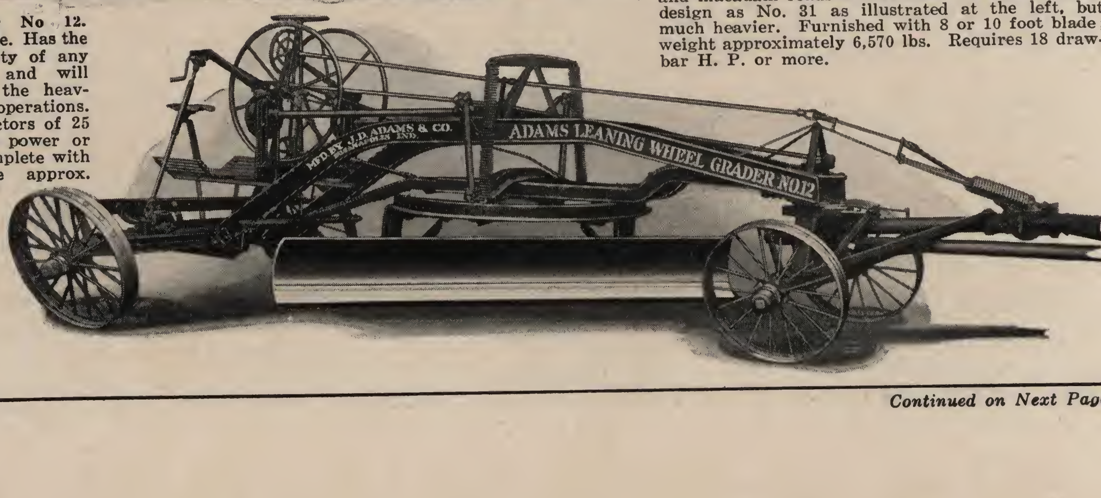
Grader No. 8: With 8 foot blade; for use with eight horses or tractors of 10 to 20 drawbar H. P. Same design as No. 12 shown below. Popular all purpose machine. Weight with eight horse hitch approximately 4,095 lbs.; with steerable engine tongue approximately 4,345 lbs.

Grader No. 10: With 10 foot blade; same design as No. 12 shown below. A heavy duty machine for use with tractors of 15 drawbar H. P. or more. Furnished with engine tongue only; weight 6,170 lbs.

Grader No. 12: See illustration and description below.

Scarifier-Grader: Powerful scarifier and grader in one. Can be used in combination or separately. For scarifying and regrading old gravel, stone, and macadam roads and streets. Of same general design as No. 31 as illustrated at the left, but much heavier. Furnished with 8 or 10 foot blade; weight approximately 6,570 lbs. Requires 18 drawbar H. P. or more.

Adams Grader No 12. With 12 ft. blade. Has the greatest capacity of any grader built and will easily handle the heaviest grading operations. Used with tractors of 25 drawbar horse power or more. Wt. complete with engine tongue approx. 7,550 lbs.



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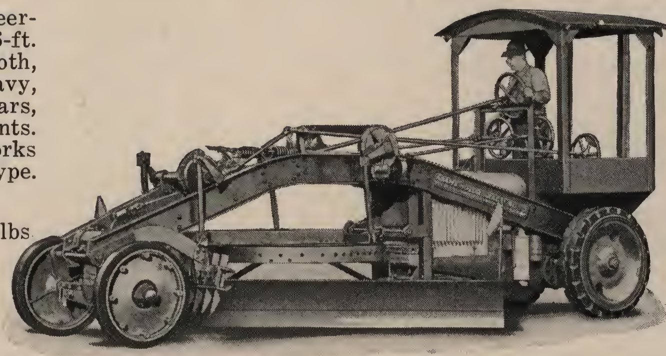
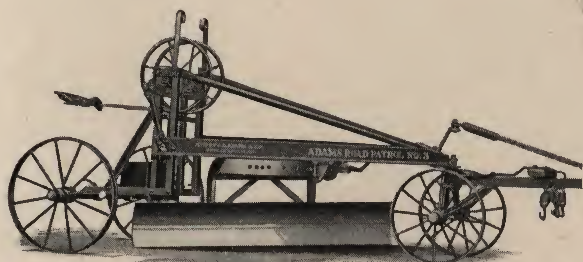
Adams Motor Grader No. 10: Using McCormick-Deering 10-20 tractor furnished with 10, 12, 14 or 16-ft. blades. The strongest, most rigid and most smooth, cutting motor grader of its size ever built. Extra heavy, all riveted construction throughout with enclosed gears, machine finished bearings and ball and socket joints. Has new and exclusive type of blade control that works 50 per cent faster and much easier than ordinary type. Furnished with or without scarifier and cab.

Approximate weight without scarifier or cab 11,780 lbs.
Wt. of scarifier 960 lbs.
Wt. of cab 400 lbs.

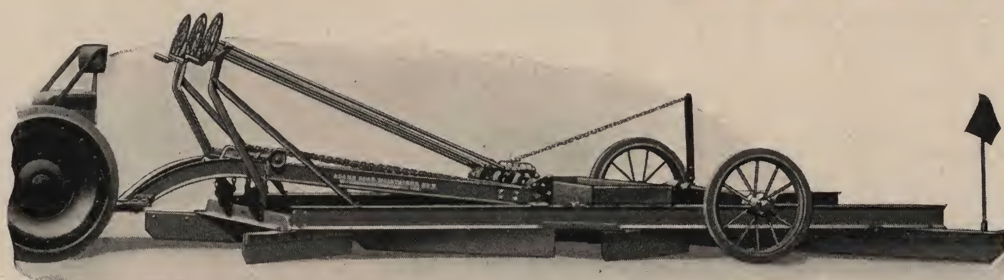




Adams Road Patrols: Most rigid and smooth cutting. Their distinctive triangular design gives them a rigidity, strength and durability not equalled by any other patrol. Have ball and socket joints and adjustable bearings in blade control which permit no lost motion. Very easy and convenient to operate.

No. 3,	6½ foot blade,	for 2 or 3 horses.	Wt. approx. 1,055 lbs.
No. 4,	8 foot blade,	for 2 or 3 horses.	Wt. approx. 1,095 lbs.
No. 41,	8 foot blade,	for 2 or 3 horses.	Wt. approx. 1,375 lbs.
No. 5,	8 foot blade,	for 2 to 4 horses.	Wt. approx. 1,695 lbs.
No. 6,	10 foot blade,	for 2 or 4 horses.	Wt. approx. 1,760 lbs.

Above weights are without hitches



Adams One-Man Road Maintainer No. 6: Can be hitched to any tractor—operated by tractor operator. Has 7 blades with a total length of 40 feet. These blades work the road surface four times in one trip, completely cutting off high places, filling holes, and leaving the road absolutely smooth. Is a "sure fire" chatter bump remover.

Regularly cuts 9 feet wide; with extensions 10½ or 12 ft. Scarifier attachment can be put on ahead of the front blades. The machine, without scarifier or blade extensions, weighs approximately 3,330 lbs., and the cutting pressure on the ground can be regulated from 0 to 3,300 lbs. by the three operating controls.

Stroud Elevating Graders and Dump Wagons—Standard for 25 Years: Among dirt movers everywhere Stroud Graders and Wagons have been favorites for many years because of their durable construction and light draft. They are now sold exclusively by J. D. Adams & Co. and offered in the following sizes:

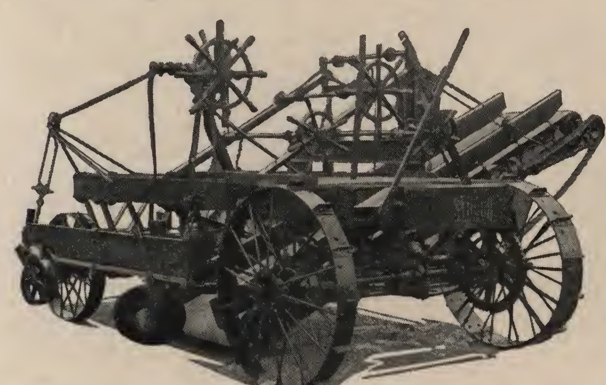
Stroud "Little Red" Wagon—2 yd. capacity (illustrated below) weight 2,010 lbs.

Stroud "Special" Wagon—1½ yd. capacity. Weight 1,865 lbs.

Stroud Senior Grader—(illustrated) with 36 in. belt. Weight approximately 9,975 lbs.

Stroud Master Grader—(same type but heavier) with 36 in. belt. Weight approximately 11,680 lbs.

Stroud Heavy Duty Grader—same as Master Model except has 42 in. belt. Weight approximately 11,790 lbs.



C. D. EDWARDS MFG. CO., INC.

Albert Lea, Minnesota

Makers of Edwards Earth Moving and Maintenance Equipment

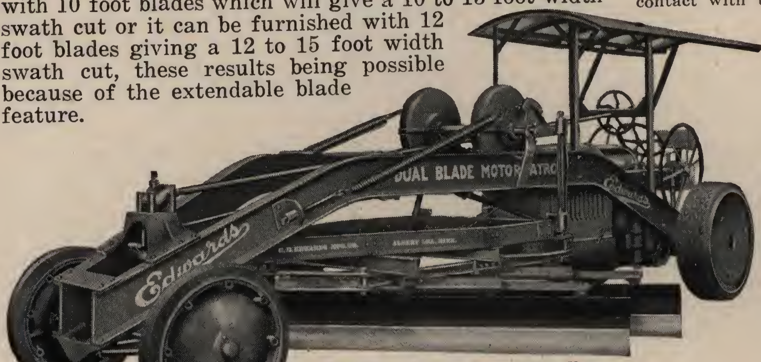
DISTRIBUTORS AT

Albert Lea, Minn.	Enid, Okla.	Kansas City, Mo.	Pittsburgh, Pa.	Sioux City, Ia.
Atlanta, Ga.	Fargo, N. D.	Little Rock, Ark.	Peoria, Ill.	Terre Haute, Ind.
Dallas, Texas	Fort Dodge, Ia.	Linesville, Pa.	Seattle, Wash.	Wheeling, W. Va.
Denver, Colo.	Havelock, Nebr.	Los Angeles, Calif.	Sioux Falls, S. D.	

Products: Tractor Graders for Road Building, Motorized Maintenance Graders, Patrol Graders, Graders for Maintenance with Rubber Tires and Timken Bearings, Scarifying Graders, Backslopers, Road Drags, Wheeled Scrapers, Drag Scrapers, Fresno Scrapers, Road Plows, Road Rooters, Pure Iron and Steel Culverts, Intake Grates for Tile, Edwards No. 5 and 10 Bar Iron Shears, Waterloo Bar Benders No. 2 and 3, Rotary Snow Plows, Cutting Edges for All Makes of Graders.

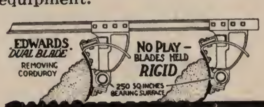
Edwards Dual Blade Motor Patrol: A machine designed after years of practical research and experiments with the merits and failures of all types of motorized equipment. It will give maintenance results you have never before experienced in a single blade machine.

Extendable Blades: This machine can be furnished with 10 foot blades which will give a 10 to 13 foot width swath cut or it can be furnished with 12 foot blades giving a 12 to 15 foot width swath cut, these results being possible because of the extendable blade feature.

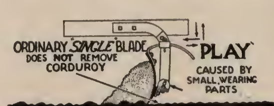


Weight 13,100 lbs. Wheelbase 18′ 6″. Furnished with 32x5 rubber tire front wheels, 40x10 rubber tire rear wheels. 10-20 McCormick-Deering Tractor.

The Dual Blade Removes the Corduroy or "Washboard" Road: The elementary principle of a road drag combined with a long wheelbase is the foundation on which the Dual Blade Motor Patrol has been built. Do not be confused, however, that the above machine is only a road drag on wheels; to the contrary, it combines the best engineering, the most thorough construction and mechanical completeness that has ever been offered in a piece of motorized equipment.



The Right Way

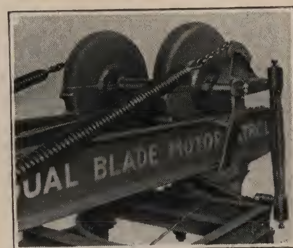


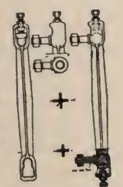
The Wrong Way

Two blades will not follow the corduroy in a road, they will not gouge or chatter. A road drag will never make a washboard road. The reason for this is simple, as one blade steadies the other during cutting; in fact, one blade will be found to function as the wheelbase or "Steady rest" for the other, therefore, neither blade can gouge and make deeper the "corduroy" in the road, but instead the blades will shear off the high places and deposit the loose dirt or gravel in the low places. The operator can control, from the rear platform, the depth of cut of either blade.

Anyone who has ever followed a single blade maintenance machine, whether it be horse-drawn or motorized, has always had occasion to notice how the single blade vibrates over the "corduroy" or "washboard" and in reality removes very little of it. More often the blade makes it worse than before. **Regardless** if adequate take-ups were provided and **Large** wearing areas were incorporated, which will hold the blade rigid with the frame of the machine, yet there is ever present the jumping and chattering of the single blade machine when doing even the smallest amount of cutting on a gravel or dirt road.

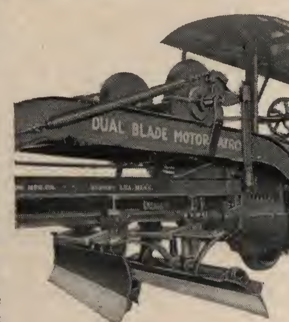
Direct Connected Lifting Gears: This type of construction is another very welcome departure. Instead of locating the lifting gear and worm to the rear of the machine next to the operator, we locate it directly above the blades. By this direct connection, we eliminate at least seven **Chances** for the development of play in the lifting gear assembly.

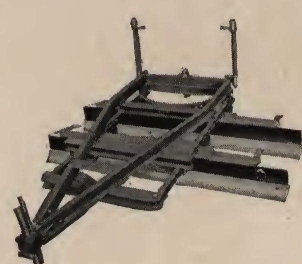




A 25″ diameter lifting gear, which is from one to three times larger than has been previously offered by any manufacturer, gives an enormous leverage on the blades, easy raising and lowering, fast operation and more teeth of the worm in contact with the gear than would be the case if the gear were a small one. The result of the last feature will be longer wear with less play developing.

We eliminate all possible **Chance** for play between the gear and the lifting arm by making these two parts from one homogeneous mass of metal, therefore no play or lost motion can possibly develop between the lifting arm and the lifting gear.





Tilting Blades: Either blade will tilt independently of the other to an angle of 60 degrees. The front blade can be left in a vertical position to do the cutting and the rear blade can be tilted to do the smoothing or troweling as is shown in the above photograph. In case of very muddy roads both blades can be tilted forward to the extreme angle, thereby putting downward pressure on the loose soil rather than carrying it in the curve of the mouldboard. The angle of these adjustments is far more than is ordinarily furnished on any other motor patrol.

Extendable Blades: By a simple adjustment requiring no wrenches or tools, the operator can slide either one or both blades to the right or left. In the extreme position in either direction, they will reach 58″ outside of the rear wheels. On a machine equipped with 12′ blades a maximum swath cut of 15′ can be effected by extending the front blade in one direction and the rear blade in the other.

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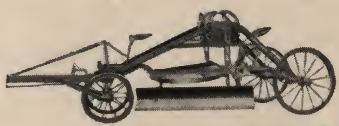
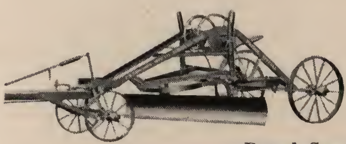


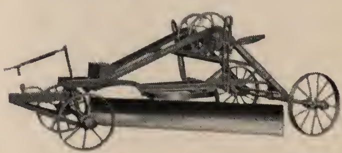
Service Patrol

Weight 1,238 lbs. Wheelbase 8′ 4″. Furnished with 6′, 7′, 8′ or 10′ length mouldboards.



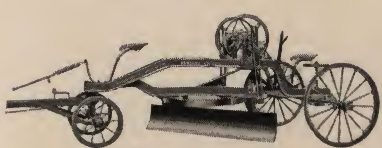
Patrol Special

Weight 1,448 lbs. Wheelbase 8′ 10″. Furnished with 6′, 7′, 8′ or 10′ length mouldboards.



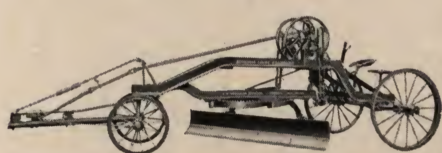
Junior

Weight 1,596 lbs. Wheelbase 8′ 10″. Furnished with 6′, 7′, 8′ or 10′ length mouldboards.



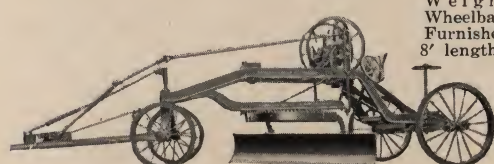
Comet

Weight 1,773 lbs. Wheelbase 9′ 7″. Furnished with 6′ and 7′ length mouldboards for grading and 8′ and 10′ length mouldboards for maintenance.



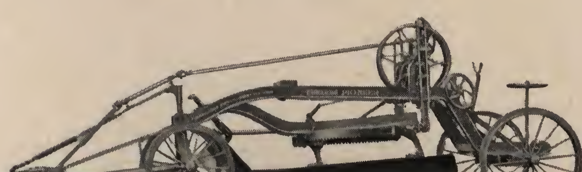
Light Standard

Weight 2,185 lbs. Wheelbase 10′ 7″. Furnished with 7′ length mouldboard for grading and 8′ and 10′ length mouldboards for maintenance.

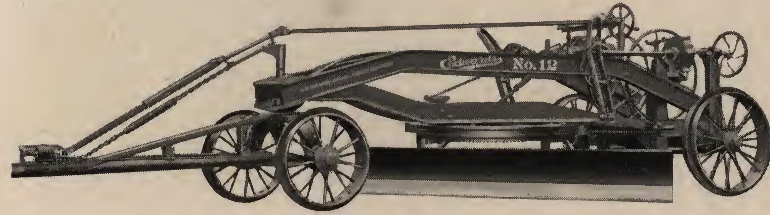


Chief Standard

Weight 3,165 lbs. Wheelbase 10′ 10″. Furnished with 7′ or 8′ length mouldboards.

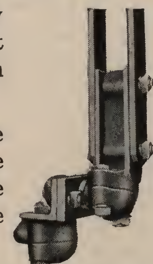


Pioneer



Big Bertha No. 12

Service Patrol: An exceptionally sturdy machine built for two to four horses. It is very rigid and free from all play in joints.



Ball and Socket Joints: All graders are fitted with ball and socket joints where wear is most liable to develop. Large round machined balls of the highest grade are used.

Patrol Special: Built for a heavier class of maintenance than the Service Patrol and is highly successful for maintenance with from two to four horses. The circle is suspended on five large ball joints. Take-up provisions throughout. An exceptionally rigid machine.

Junior: This machine has received great favor from the townships when equipped with 7′ blade and used for road repairing and construction with from four to six horses. Can be furnished with angle tires, offset truck for tractor. An exceptionally rigid machine, easy to operate and dependable.

Comet: Especially adaptable to all types of township work. Requires six to eight horses or eight to twelve drawbar horsepower tractor. Rigidly built of the finest material and workmanship. Ball and socket joints used throughout. All adjustments made from the operator's platform. Exceptionally dependable and will last a lifetime.

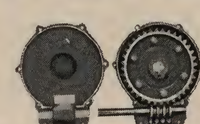
Light Standard: An unusual favorite because of its adaptability to the size tractor found on most farms and is seldom found idle for this reason. Requires ten to fifteen drawbar horsepower tractor and will fit a requirement where a lighter or heavier machine will fall down completely.

Chief Standard: An exceptionally rugged machine, easy to handle and a glutton for moving earth at the least possible cost per mile. To be used with a twelve to eighteen drawbar horsepower tractor. Breakage on this, as well as other Edwards machines, is reduced to practically nothing on account of steel and malleable castings used throughout. It is beyond a question of a doubt a most dependable machine and the manner in which it handles an enormous load will be pleasing to even the most exacting operator.

Pioneer: Weight 4,218 lbs. Wheelbase 11′ 10″. Mouldboard—8′ length for grading, 10′, 12′ or 16′ for maintenance. Built to stand up under the most severe abuses that this size of machine could possibly be put to. Suitable for tractor with fifteen to twenty-five drawbar horsepower. Extra heavy construction, including steel and malleable castings, is used throughout. This machine will operate easier than any 8′ grader and records show that it is one of the lowest upkeep cost per mile grader that has ever been built.

Big Bertha No. 12: Weight 9,775 lbs. Wheelbase 16′ 9″. Blade length 12′.

Timken bearings in wheels standard equipment, also inclosed cut bronze gears and cut steel worms running in bronze bushings are standard. It is a machine for users who have had experience with all other makes and are in a position to know that it is not the first cost of a machine that counts. A very easy operating machine and a thoroughbred both as to its construction, operation and earth moving ability.



THE GALION IRON WORKS & MANUFACTURING CO.

Plant and General Offices—Galion, O.

Road Building and Maintenance Machinery

BRANCHES AND DISTRIBUTORS LOCATED AT (see Geographical Index for street addresses)

Penn Yan, N. Y.	Nashville, Tenn.	Orlando, Fla.	Hutchinson, Minn.	San Antonio, Tex.	Spokane, Wash.
New York City, N. Y.	Greensboro, N. C.	Sault Ste. Marie, Mich.	Hastings, Neb.	Houston, Tex.	Portland, Ore.
Harrisburg, Pa.	Columbia, S. C.	Milwaukee, Wis.	Omaha, Neb.	El Paso, Tex.	Butte, Mont.
Pittsburgh, Pa.	Atlanta, Ga.	Indianapolis, Ind.	Des Moines, Ia.	Amarillo, Tex.	Salt Lake City, Utah
Roanoke, Va.	Birmingham, Ala.	Rockford, Ill.	Kansas City, Mo.	Dallas, Tex.	Denver, Colo.
Huntington, W. Va.	Mobile, Ala.	McLeansboro, Ill.	Oklahoma City, Okla.	Seattle, Wash.	San Francisco, Calif.

Los Angeles, Calif.

Export Dept.—F. H. Conklin and W. G. Harrington, Inc., 50 Church St., New York City

Galion products are made in the World's Largest Road Machinery Plant, The Galion Iron Works and Mfg. Co., Galion, O. A big new building, 90x340, completed early in 1928, has added to the size of the plant.

Back of the line are twenty years of experience in designing, manufacturing and marketing road machinery.

The Galion line is the progressive line. The machines included in the line are modern and up-to-date, and will always prove satisfactory.

Prompt Shipment: Large stocks of completed Galion Rollers, Graders and Contractors equipment are carried in stock at all times at the plant and in big branch and distributors' warehouses in various parts of the country. You will get prompt shipment always when you order a Galion machine.

Galion Products: Galion Road Machinery is without question the most complete line produced by any road machinery plant in the world. The following list covering the most important items in the line is for your guidance in requesting literature and more complete information.

Galion Rollers:

Master 4-Cylinder Motor Roller 10 or 12 tons

Steam Roller 10 tons and up

International Rollers 5, 6, 7 and 8 ton sizes with Scarifier and Planer

Junior (Fordson Powered) Rollers 3 to 7 ton sizes with Scarifier and Planer

Fordson Special Rollers (not geared) 3, 4, and 5 tons

Tandem 4 cylinder Motor Rollers 5, 6, 7, 8, 9 and 10 tons

Tandem Steam Roller 5, 6, 7, 8, 9 and 10 tons

Galion Motor Graders: E-Z Lift (rear control) Motor Graders, powered by Caterpillar, Cletrac, Twin City, McCormick-Deering and Fordson tractors.

Standard (center control) Motor Graders, powered by McCormick-Deering and Fordson tractors.

Galion Drawn Graders:

E-Z Lift Engine Graders in eight sizes and styles with mouldboards 7′3″ to 12′

Leaning Wheel E-Z Lift Graders in five sizes with mouldboards 7′ to 12′

Premier Graders in four sizes with mouldboards 6′ to 8′

Premier Maintainers

Blades for all makes of Graders and Drags

Other Galion Products:

Belt Conveyor and Grizzly Hopper

Unloading Plants with 18, 25, 50 and 125 ton bins

Gravel Screening Plant

Heavy Duty Fresnos

Dragline Scraper or Bucket

Stone Spreader

Rock Crusher

Wheel and Slip Scrapers

Road and Rooter Plows

Road Drags

Cast Iron Culverts and Catch Basin Covers

Galvanized Corrugated Culverts

Write for general catalog or special bulletins on any of these products.

Galion Motor Graders: Fully perfected in line with the needs of road men. Approved by owners in all parts of the United States. Galion Motor Graders offer proven and exclusive advantages found in full in no other motor grader. Among these advantages are the following:

Lift springs which help in mouldboard raising.

Extra large lift wheels.

E-Z Lift Worm Gearing, machine cut and operating in a bath of oil at BOTTOM of an oil-tight gear case.

Heavy frame (21¼ lb. per lineal foot, 30 lb. on Twin City), fully reinforced.

Extra curved mouldboards in 8, 10, 12 or 14 foot lengths.

Powerful scarifier, controlled by enclosed machine-cut worm gearing.

Snow plow attachment, practical and effective.

Firm-balance front block of new design.

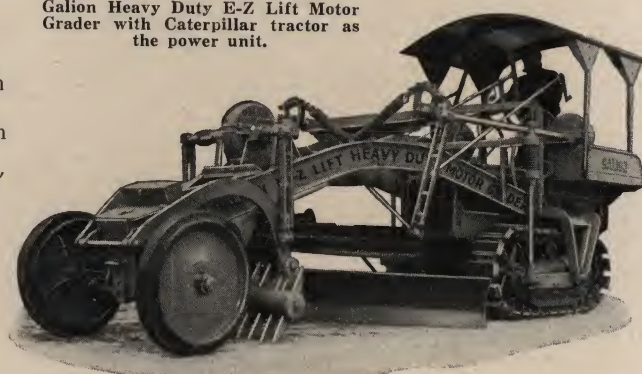
Galion E-Z Lift (rear control) Motor Grader parts are made for use with McCormick-Deering, Fordson, Twin City, Cletrac and Caterpillar tractors.

Galion Standard (center control) Motor Grader parts are made for use with McCormick-Deering and Fordson tractors.

Both types of Galion Fordson and McCormick-Deering Motor Graders are supplied with crawlers or rubber tired rear wheels, as preferred.

Illustrated descriptive bulletins on any of these motor graders will be sent promptly on request.

Galion Heavy Duty E-Z Lift Motor Grader with Caterpillar tractor as the power unit.



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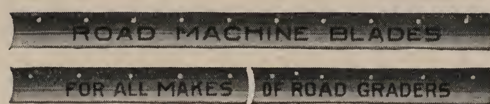
Galion E-Z Lift Graders: Galion E-Z Lift Graders in eight sizes and styles are well known as the easiest operating road graders ever designed. They are modern in every detail and have no superior in the field.

Galion Leaning Wheel E-Z Lift Road Graders: With the other advantages of the E-Z Lift Line these graders combine a leaning wheel adjustment of the simplest, most practical type. Control is by self-locking machine-cut worm gearing in a bath of oil; two pinions and segments are used both front and rear, and in other ways this leaning wheel adjustment is superior to any heretofore used.

A new feature in the grader field is the Simplex pivotal frame adjustment which is especially suited to the leaning wheel grader and which gives added strength with much greater durability and ease of operation. Galion Leaning Wheel E-Z Lift Graders are made in sizes for 8, 9, 10 and 12 foot mouldboards.



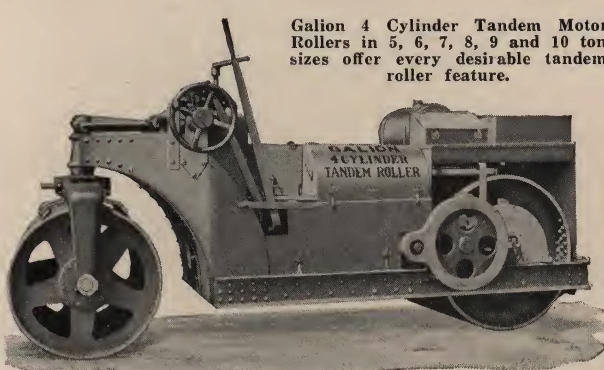
Galion Grader Blades of special high carbon manganese steel are made to fit all sizes of Graders and Drags.

This big roller in 10 or 12 ton weights has proven its right to the name, "Master." It has won universal approval from coast to coast.

Galion Road Rollers: Galion Rollers with both motor and steam power in both macadam and Tandem types form a complete proven line—a roller to meet every need of service.

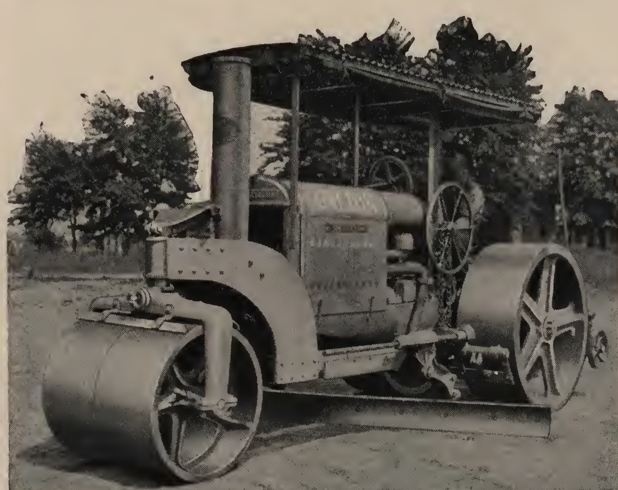
Galion small rollers are equipped with sturdy scarifiers and fully adjustable, under-the-roller planers. They are made in four types in weights of 3 to 8 tons, with Fordson or McCormick-Deering 10-20 tractor as power unit.

The International Roller illustrated below is made in 5, 6, 7 and 8 ton weights and can be supplied with either hand operated or air pressure scarifier.



Galion 4 Cylinder Tandem Motor Rollers in 5, 6, 7, 8, 9 and 10 ton sizes offer every desirable tandem roller feature.

Extra curved mouldboard, enclosed lift springs and machine cut E-Z Lift worm gearing operating in oil at the BOTTOM of an oil-tight gear case, are three of many good features.



THE GOOD ROADS MACHINERY COMPANY, Inc.

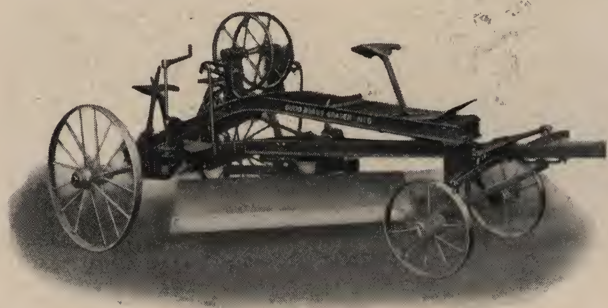
Kennett Square, Pennsylvania

Crushing and Road Making Machinery

Branch Offices:

Watertown, Mass., 36 Pleasant St.
Portland, Ore., Third and Hawthorne Sts.
Chicago, Ill., 49th and Halsted Sts.
San Francisco, Calif., 26 Fremont St.
Pittsburgh, Pa., 1523 Oliver Bldg.
Philadelphia, Pa., 420 Commercial Trust Bldg.
Los Angeles, Calif., 931 Santa Fe Ave.
Atlanta, Ga., 569 Whitehall St.
New York, N. Y., 50 Church St.

Products: Graders, Horse and Tractor Drawn, Road Rollers, Pressure Heating Distributors, Portable Rock Crushers, Gravel Machinery, Car Unloaders, Road Drags, Snow Plows, Etc.

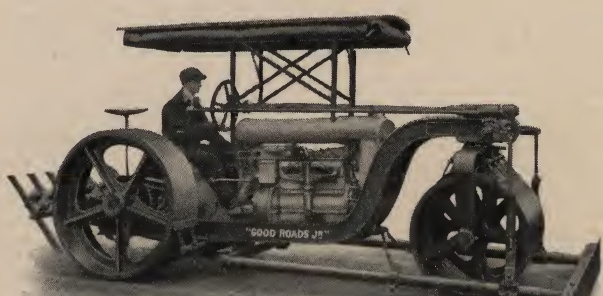


No. 6 Good Roads Grader: One of six sizes of graders built by this company. It is constructed of 4 in. channel iron, 22 in. and 42 in. diameter wheels, front and rear respectively, wheel hubs so designed that either plain sleeve or roller bearings can be used. Standard blade is 6 ft. by 12 in. by $\frac{3}{8}$ in. and maintenance blade, 8 ft. by 8 in. by $\frac{5}{16}$ in. can be furnished when desired. Total weight approximately 1,600 lbs.

Good Roads Motor Grader: This desirable unit can be furnished with either McCormick-Deering 10-20 Tractor or Cletrac Model 20-K. The design is such that the blade has sufficient stability to perform with utmost

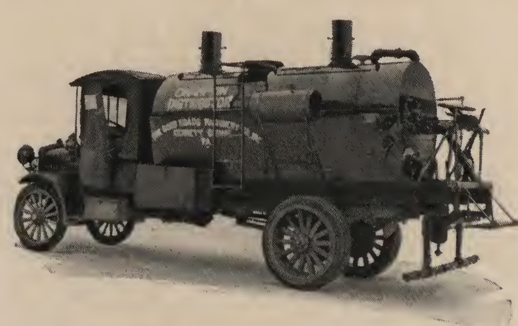
efficiency at all times. The scarifier attachment has ten reversible picks.

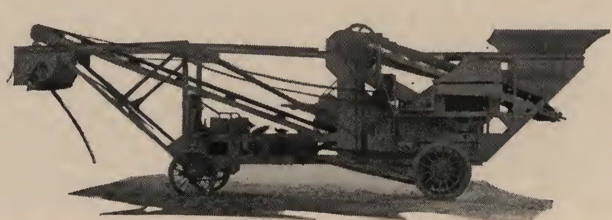
There is also a snow plow for attachment to this unit, thereby permitting 12 months service under all conditions. Send for pamphlet.



Good Roads Jr. Roller: Four machines in one—roller, scarifier, leveler and scraper. Also will pull sprinkler, grader or supply wagon. Geared low to develop 50% above usual Fordson power. Low gas and oil consumption.

Champion Distributor (below): Applies all grades of bituminous binder equally well. Distributes $\frac{1}{8}$ to 2 gallons per sq. yd. 600-, 800- or 1000-gallon tank as desired. Can be mounted on any standard truck. Oil burner gives any heat required. Pressure generated by powerful pump. Flow regulated by self-acting valves.



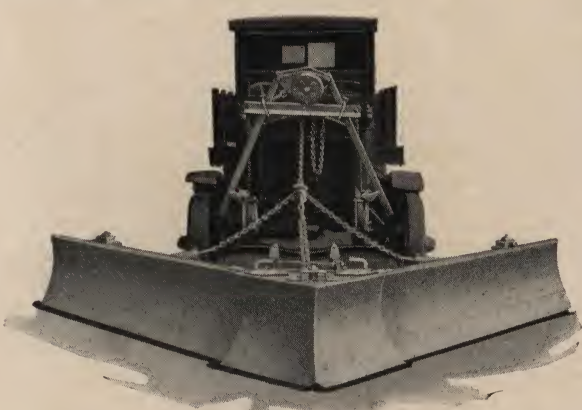


Good Roads Portable Gravel Crushing and Screening Plant: Contains a 10x30 in. fine reduction crusher equipped with Timken roller bearings and SKF boxes, 4 cu. yd. capacity intermediary hopper, grizzly, two Timken equipped conveyors. Screen is 3x6 ft. vibrating type. Entire unit is carried on Timken bearing rubber tired wheels. Weight complete, approximately 12½ tons.

Continued on Next Page

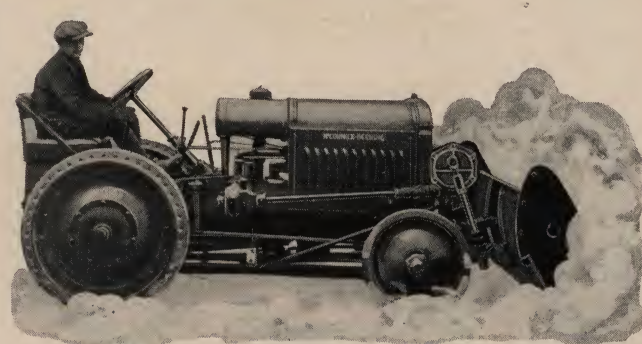
Good Roads Sand Spreader: An individual motor unit operates the sand spinner and conveying screw, delivering sand from a 6 cu. yd. capacity bin through a chute to the revolving disc. Can be mounted on practically any standard make 5-ton truck. The spreader will normally throw over a 9 ft. width of roadway. This is the furthest step yet taken to prevent accidents from slippery pavements.

Good Roads Hi-Speed Snow Plow: Model 21-B, shown at right. Especially adapted for country highway use. Combines the best features of both bar type and "V" type plows. With adjustable blades open, it will clear a 14-foot path at 15 to 20 miles an hour. Blades can be closed independently of each other, a decided advantage in meeting traffic. Can be set to scrape surface clean or to leave as much snow on the highway as may be desired.



Repair Parts: The Good Roads Machinery Company, Inc., maintains a Repair Part Department that has earned a reputation for unusual service. Parts are manufactured on a large scale and stocks are constantly on hand in warehouses at strategic points throughout the country.

Good Roads Champion Blade Type Plows: The illustration shows Model 10-C Plow, which is one of the blade type plows of the Champion group. This plow is 20 in. high, with ¼ in. special steel moldboard, and is supplied in either 8 ft. or 10 ft. lengths, specially designed to roll the snow and keep it moving from the plow. The spring control is an individual feature of the Champion plows and permits their flexibility in operation and minimum repairs due to its design. The plow can be adjusted to clean the surface of the pavement or to leave a slight covering of snow on the ground. Either roller bearing lifting device or a two-speed lifting device is supplied, with handwheel and shaft lifting control operated from the truck cab.



Good Roads Champion Crosswalk Plow: This plow eliminates costly hand labor in piling and removing plowed windrows of snow at crossings, or to facilitate severing snow or trimming snow around a mechanical snow loader. Power lift speeds up work, and also forces cutting edge into hard packed snow, thereby cleaning down to the pavement.

Literature: Any of the following sent on request: General Road Machinery Catalog, Snow Plow Catalog, Sand and Gravel Catalog or descriptive bulletins of illustrated equipment.

WESTERN WHEELED SCRAPER COMPANY

Aurora, Illinois, U. S. A.

Earth and Stone Handling Equipment

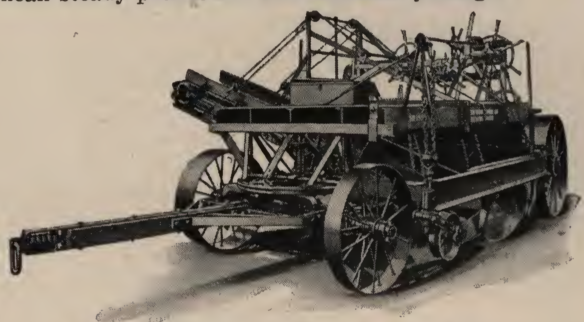
BRANCH OFFICES

Atlanta, Ga., 602 Rhodes Bldg.
Memphis, Tenn., 91 S. Front St.
Dallas, Texas, 1301 S. Lamar St.
Chicago, Ill., 29 S. LaSalle St.
Pittsburgh, Pa., 331 Fourth Ave.
St. Louis, Mo., 2918 S. Broadway
New York, N. Y., 50 Church St.

Products: ELEVATING GRADERS, STREET EXCAVATORS, DUMP WAGONS, ROAD GRADERS AND SCARIFIERS, WHEELED, DRAG, FRESNO AND TUMBLEBUG SCRAPERS, GRADING PLOWS, ROAD DRAGS, PORTABLE ROCK CRUSHERS AND GRAVEL SCREENING PLANTS, ROAD METAL PLANTS, BATCH BOXES, CAR TRUCKS AND INDUSTRIAL TRACK FOR CONCRETE ROAD WORK, HOT PATCH OUTFITS, DUMP CARS, ETC.

Western Elevating Grader: The new Western Elevating Grader is a tractor grader. Its rugged construction permits the use of power that would wreck an ordinary machine. The capacity of this machine is limited only by the power in front of it.

The elevator has been redesigned entirely to meet the suggestions of contractors in the field, to whom perfect alignment, simplicity of adjustment and easy operation mean steady production and increased yardage.



Western Elevating Grader with Disc Plow

This new machine can plow and load or cast a furrow 14″ deep and 14″ wide, increasing by 35% production by the ordinary 12″ by 12″ furrow—an increase that would pay for the machine in a short time.

Steerable offset engine-hitch furnished at extra cost when desired; 40″ carrier furnished on standard machine at extra cost when specified.

Specifications:
Weight with stub engine-hitch, 12,800 lbs.
Tread C to C, rear wheels, 8′ 0″.
Tread C to C, front wheels, 6′ 6″.

Western Dump Wagon: The Western Dump Wagon, for use with elevating grader or power shovel, combines in a remarkable degree great strength and ruggedness with ease of draft. The frame is a steel channel, wood-filled. The sides are ironed along the edges and top. Doors and top end boards are oak. Washington fir is used wherever practicable, being as strong as oak and much lighter. The wagon is unusually short-coupled, the distance between axles being 7′ 6″ and it is "low slung," making it easy to load. The height from ground to top of box is only 4′ 8″. Ease-of-draft has been promoted also by the relative height of wheels, a result of careful study. The standard height of wheels on the 1½-yd. wagon is 38″ front and 50″ rear.

Western 1½-yard Dump Wagon with Steel Bolster

The Western Dump Wagon is provided with either wood or steel bolster as preferred. A new three-up hitch is an added improvement, permitting the team to raise or lower the tongue in going over rough ground, while supporting only the weight of the tongue. Made in two sizes, 1½-yd. and 2-yd. capacity.

One and One-Half Yard Wagon:
Wheels, front, 38″ high; rear, 50″ high.
Tire, 3½″ by ½″. Track, 5′ 2″.
Height from ground to top of box, 4′ 8″.
Weight, about 2,100 lbs.
Opening for discharge of load, 44″ by 39″.

Western 7-yard Crawler Dump Wagon

Western 7-yard Crawler Dump Wagon: The Western 7-yard Crawler Dump Wagon on Athey Truss Wheels is the latest departure in contractors' dump wagons. It is an all-steel wagon of great strength, and like all Western machines is of hot-riveted construction as far as is practicable. It reaches its greatest efficiency when loaded by an elevating grader, but is strong enough to stand up under a power shovel loading rock.

The Athey Truss Wheels, which carry 90 per cent of the load, present an area of nine square feet to the ground. Due to their special construction, so little ground resistance is offered that under normal conditions a single 60-horsepower "Caterpillar" can handle a train of two loaded Western 7-yard Crawler Dump Wagons. Weight, about 10,000 lbs.

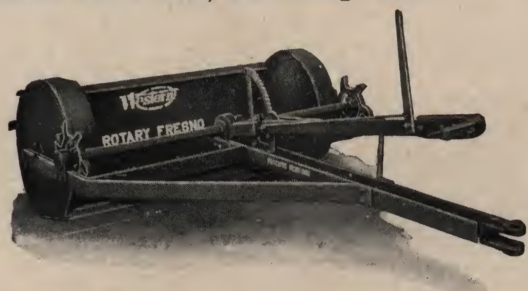
This wagon, with its broad wheels, will operate under the most adverse haulage conditions. It will carry its huge load through mud and sand where an ordinary wagon would stall. It will follow your crawler type tractor under any conditions in which the tractor can operate. Write for Bulletin No. 27-S.

Western Fresno Scraper: For short haul work in railroad and highway construction there is no tool that can compete with the Western Fresno. The smaller fres-

Continued on Next Page

noes are also very practical tools for cleaning ditches and similar maintenance work. The fresno is a very economical tool because of its capacity and because one man can load and dump the scraper and handle the team. Three or four animals are required to operate sizes 1 and 2, cutting 5′ and 4′ respectively, and two animals for Nos. 3, 4 and 5, cutting 3′ 6″, 3′ 0″ and and 2′ 6″, respectively. Fresnoes are furnished with pull rods and eveners or with bails, as desired. Unless otherwise specified scrapers with eveners will be shipped.

Western Rotary Fresno: The growing demand for motorized operation has led to the development of the Western Rotary Fresno. It has all the features of design that make the standard Western Fresno so popular and useful as a tool, but it is a larger unit designed for operation with a small, fast moving tractor.



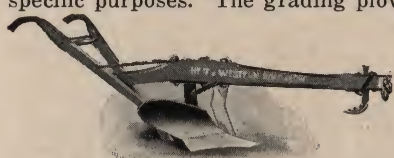
Western Rotary Fresno

In dumping the pan turns completely over and the load may be spread in a thin layer or deposited in one spot. The entire cycle, loading, carrying, dumping, and spreading, is performed without stopping or backing the tractor and is controlled by the tractor operator. Bulletin 27-G explains in detail.

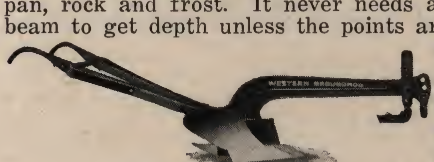
Western Drag Scraper: Western Drag Scrapers are made in several sizes. They are standard tools, superior in many ways to other drag scrapers, being more durable, more easily filled, of lighter draft, less dangerous to the team, etc., and having an extra replaceable bottom, flanged, to take the wear.

Where a cheaper scraper is desired the Illinois All-Steel Drag is furnished. While it is not as substantial as the Western, it will give satisfactory service.

Western Plows: These range from two-horse up to tractor engine plows. Western plows are designed for specific purposes. The grading plows cut a deep rather than a wide furrow, so as to place the earth in the most convenient position for taking up with scrapers. The rooter plow, the only plow with steel-faced shoe and so long a beam, is designed for tearing up turnpikes, macadamized roads, cemented walks, hard pan, rock and frost. It never needs a weight on the beam to get depth unless the points are worn out and need replacing.



Western Grading Plow No. 7



Western Groundhog Plow

The Western Groundhog is a dual purpose plow, combining the efficiency of the Western grading plow with the rooter. By removing the share and moldboard, the grading plow is converted into a rooter. Cheek plates are included for holding the reversible tool steel points when the plow is used as a rooter. Write for Bulletin 27-R.

Some of the Western Plows

	Weight, Lb.
No. 1 R. R. Plow, 6 horse	230
No. 2 R. R. Plow, 8 horse	260
No. 3 R. R. Plow, 10 horse	300
No. 4 R. R. Plow, 12 horse	450
No. 5 R. R. Plow, 4 horse	180
No. 6 R. R. Plow, 2 horse	135
No. 7 Township Plow, 2 horse	115
No. 15 Allsteel Road Plow, 4 horse	180
No. 16 Allsteel Road Plow, 2 horse	135
No. 20 Rooter Plow, 8 horse	275
No. 25 Rooter Plow, 12 horse	430
Western Groundhog, same size as No. 20.	
Western Giant Hardpan Plow, 12 horse	580
No. 33 Western Wing Plow, 8 horse	500
No. 35 Western Wing Plow, 6 horse	300
No. 36 Western Wing Plow, 4 horse	200

Western Wheeled Scraper in Carrying Position

Western Wheeled Scraper: The Western Wheeled Scraper is well known, having been a standard tool for more than fifty years. Standard Wheeled Scrapers are furnished in five sizes, No. 0, No. 1, No. 2, No. 2½, and No. 3. A light scraper, known as the Western Township Wheeler, is furnished in two sizes at a somewhat less cost.

Western Tumblebug: This is a new earth-handling machine of great capacity for long hauls. It is a scraper built on entirely new principles, designed to fill the gap between the fresno and the dump wagon. It is as simple as a wheeler and only about half as hard on the operator. Using a tractor and a train of three Tumblebugs, one man can handle three cubic yards in a single trip, loading and dumping one scraper at a time.

Capacity, 1 cu. yd.
Length of cutting edge, 5′.
Weight, approximately 1,300 lbs.

Western Batch Boxes: Western Batch Boxes, discharging their loads through the bottom for purposes of speed and saving of labor, are built substantially of oak or steel in all practical sizes to meet the mixer requirements in modern concrete road construction.

Western Heavy-Duty Truck with Brake

Western Road Builder's Car Truck: Several types of trucks for carrying batch boxes are built. The Western Heavy Duty Truck was designed to permit maximum production with minimum delays and cost of up-keep. It will carry easily two batch boxes of 37 cubic feet capacity.

THE KLAUER MANUFACTURING COMPANY

Dubuque, Iowa

Snogo Snow Removers, Maintainers, Scarifiers, Culverts

Products: SNOGO SNOW REMOVERS, MAINTAINERS, SCARIFIERS, CULVERTS, MANHOLE RINGS, INLETS, HEAD GATES, SHEET METAL BUILDING PRODUCTS, VENTILATORS, FIREPLACE EQUIPMENT, METAL CEILINGS, ROOFINGS, SHINGLES, PORTABLE ELECTRIC WELDERS, REFRIGERATOR CAR HEATERS.

Klauer-Jarmin Road Fixer: Designed and built specifically for road maintenance.

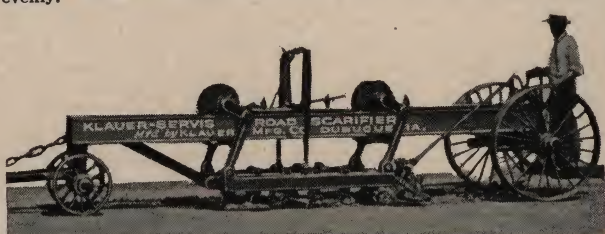
Important points of Klauer-Jarmin superiority:

1. Long wheel base, 13-foot—gives plane-like smoothness of work, eliminating "wash board" surface that is subject to ruts, pot holes and poor drainage.
2. Blades hold to work without chatter or loose play, due to raising control being connected to crank axles instead of to blades.
3. Two blades assembled in a unit permit each blade to steady the other.
4. Blade assembly floats in sub-frame guides; draft direct from front of machine and not through frame.
5. Raising control attached to separate rear crank axles raises the entire frame and blades together, and when blades are lowered, throws the full weight of machine and operator upon the blades.

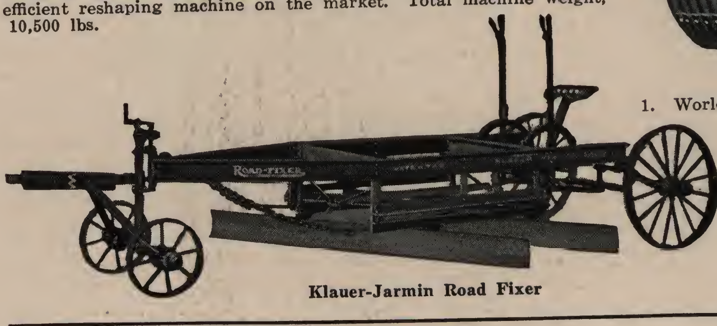
The Klauer-Jarmin Road Fixer occupies an unique place in the highway maintenance field because of its ease of operation, uniform work, freedom from complications and speed in service.

Klauer-Servis Scarifier: A heavy duty machine embodying the following necessary requirements in a scarifier:

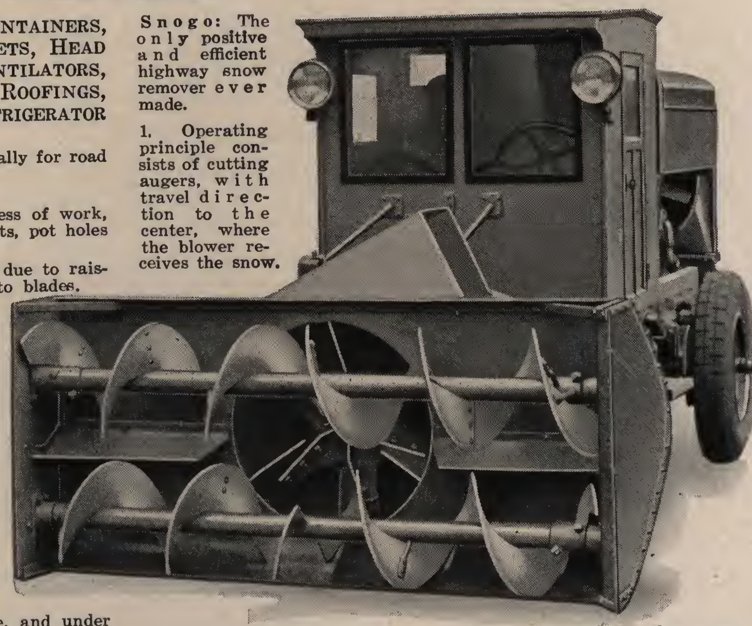
1. A long wheelbase—14½ feet.
2. The tooth block must be in the center of machine, and under positive control.
3. Tooth block must be heavy, so its weight will serve as a shock absorber. Tooth block alone weighs 3,000 lbs.
4. The raising and lowering mechanism of the tooth block must be positive so there is no lost motion.
5. Tooth block must be supported at four different corners so that there is no rock from side to side as the strain is shifted from one side to the other under uneven road conditions.
6. The teeth must be set in an inverted V position to thoroughly break up and pulverize the material so it will pack quickly and evenly.



7. The draw-bar pull must be direct to the tooth block. The use of the Klauer-Servis Road Scarifier eliminates disturbing the solid sub-base, as the teeth are set to cut only as deep as the corrugations or chuck holes. Cut can be made ⅛ inch deep or as deep as 9 inches. The 4 arms carrying the tooth block all raise and lower together, so all the teeth cut the same depth at all times. The construction of the Klauer-Servis Road Scarifier makes it the only efficient reshaping machine on the market. Total machine weight, 10,500 lbs.



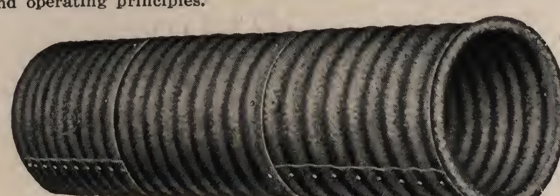
Klauer-Jarmin Road Fixer



Snogo: The only positive and efficient highway snow remover ever made.

1. Operating principle consists of cutting augers, with travel direction to the center, where the blower receives the snow.
2. There is practically no depth of snow limit for this machine.
3. It handles snow in any condition—wet,dry, hard, soft or icy.
4. Machine is made as a complete unit. One engine only is required to operate the augers, blower and propel the machine.
5. Direction of blower delivery can be changed instantly from cab, to right or left, high or low. Raising and lowering of front operating hood is also controlled instantly from cab.
6. Makes an eight-foot cut and additional cuts may be taken any width up to eight feet, in either direction.
7. Completely removes snow from the entire roadway, even beyond the shoulder, permitting drainage from roadway during thaws and spring break-up.
8. Front operating hood can be lowered down to the roadbed as shown in illustration, thus removing all snow.
9. Machine propulsion requires little power as the augers cut their own way through. The blower requires the most power and it is amply provided by a 6-cylinder motor of 125 H.P.
10. Snogo is equipped with 8 speeds—6 forward, ranging from ½ mile per hour up to 20 when not in operation. This high travel rate enables storage in heated garages at night as machine can be quickly taken to and from place of operation. The speed range also has the material advantage of quick travel between locations of the deeper drifts.

Total machine weight, 11,500 pounds. Width over all, 8 feet. Length over all, 23 feet. Pneumatic tires. Machine throughout built to best modern engineering practice in materials, simplicity, and operating principles.

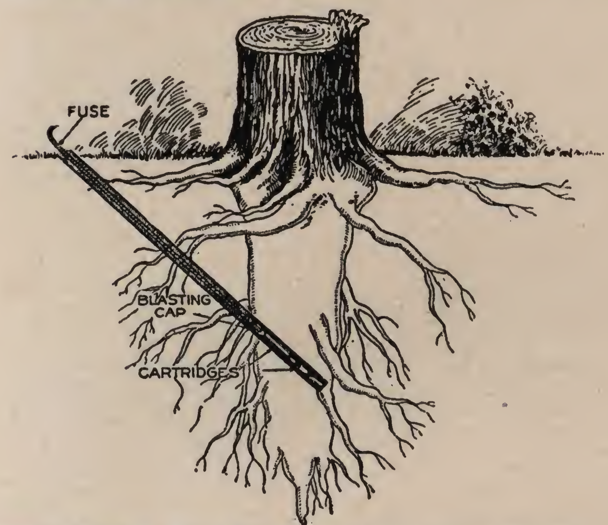


Corrugated Metal Culverts

1. World's Largest Culvert Manufacturers.
2. 21 years of experience in culvert manufacture.
3. One-half inch wider sheets used. Accordingly deeper corrugations and wider joint lap.
4. Specially selected sheets and rigid requirements of coatings.
5. Made in grades, weights and coatings to meet all Federal and State Specifications.
6. Largest range of capacity both in gauge and diameters.
7. Engineering service on head wall and installation.
8. Round nestable and flat bottom culverts made in addition to standard round.

Explosives in Road Work

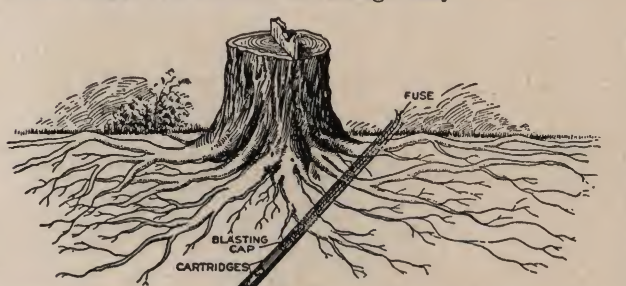
Explosives are used for many purposes in road work. These include removing stumps and boulders; loosening hard ground in grading; blasting rock in grading; blasting for surfacing material; opening ditches, and opening vertical drains. We are indebted to Hercules "Modern Road Building and Maintenance" for the matter in this section dealing with blasting stumps and boulders and to the du Pont Blasters' Hand Book for that dealing with blasting cuts.



Charge Properly Placed for Blasting Stumps Having Tap Roots.

Blasting Stumps.—There are two methods of placing the charge in blasting tap-rooted stumps.

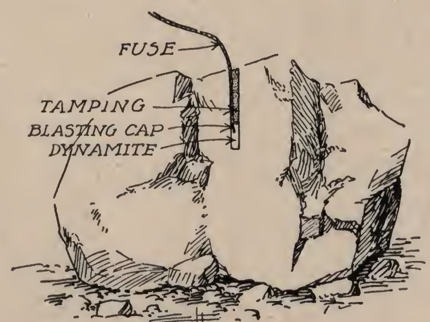
When the brace roots are small, and it is desired to use a minimum of powder at the expense of a little more labor, the best way is to expose the tap root to a depth of 18 in. or 2 ft., or to make a hole with a soil auger or punch bar that will strike the root about 2 ft. below the surface. A hole is then bored with a wood auger somewhat more than half through the root. In loading, the cartridges should be split, and all of the charge packed into the hole in the wood if possible and the remainder of the hole then filled to the surface with moist clay or other available stemming material and well tamped. Where much work is involved, a boring machine with a power-driven auger can be used advantageously.



Charge Properly Placed for Blasting Stump Having Lateral Roots.

Where the boring of the root or the stump involves too much time or expense the stump may be removed by simply placing at least 2 ft. below the surface of the ground, but snug up against and symmetrically around the tap root, two or more charges of dynamite which are then exploded by a blasting machine. Sometimes a single large charge is placed in this manner. This method requires more powder, but less labor, than that described in the preceding paragraph.

If it is desired to place a heavy charge in a hole or to concentrate the load in the bottom of the hole, an enlargement of the bottom for this purpose may be effected by "springing." To spring a hole a light



Blockhole Method of Blasting Boulder.

charge of one-quarter or one-half a cartridge is exploded in the bottom.

When shooting a single hole, fuse and blasting cap are entirely satisfactory, but when there are more than one, a blasting machine should be used, so that all the holes will explode simultaneously, each, in this way, assisting the other.

The proper loading will best be determined by practical tests on the ground. The blasting of half a dozen stumps will give a very good line on the most economical amounts of explosive to use under the existing conditions.

When blasting stumps having heavy spreading lateral roots, a charge placed under the center of the stump alone might result in merely splitting the stump, the large roots remaining and holding the split pieces. This method is successful with small, lateral-rooted stumps, but in the case of large stumps charges must be placed also under each of the heavier roots, the amounts depending upon the size of the roots, which can be determined with a ¼-in. pointed steel rod or searcher. A blasting machine should be used for simultaneous firing.

When using a single charge under a small stump of this kind or under an old stump with decayed center, the load should be placed a considerable depth below the butt, so that a substantial cushion of earth will distribute the force of the explosive and prevent mere splitting of the stump.

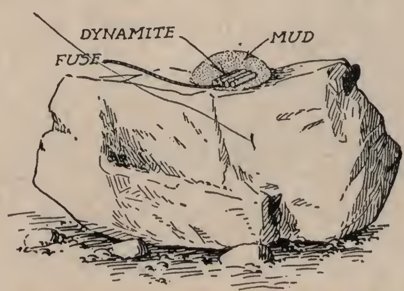
In the Pacific Coast States, redwood, fir, pine, and cedar trees grow to enormous size. Their roots usually stay near the surface, due, in a large measure, to the wet climate. These stumps can be removed in the same manner as the smaller stumps of similar type. As an indication of the amount of explosives required to remove these stumps, square the largest diameter in feet. The result will give the approximate number of 1¼x8-in. sticks necessary. This is no fixed rule, but merely indicates a point from which to start.

For blasting stumps in dense, heavy soils, such as those containing muck, clay or silt, a low strength explosive is most satisfactory. Twenty to thirty per cent strength is best for this work. In coarse, light, dry

soils, such as sand, higher strength powders, 50 to 60 per cent are required for good results.

Blasting Boulders.—There are three methods of blasting boulders: mudcapping, blockholing and snake-holing, or undermining. Mudcapping is most commonly used because it requires neither drilling nor punching of holes and causes the least scattering of pieces. The explosive is merely laid upon the rock at a point where the most effective blow might be struck with a heavy sledge hammer. The charge should be well covered with moist clay or earth, firmly packed down. Mud-capping requires practically no labor, but more powder is necessary than with either of the other two methods. It is best adapted to use on rather flat-shaped boulders having a brittle structure or well-defined lines of weakness.

With the blockholing method, a hole is drilled into the boulder, the explosive placed in the bottom of this



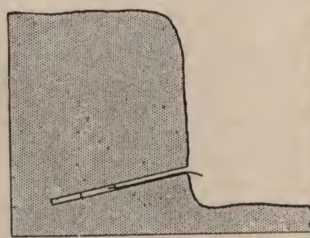
Mudcapping Method of Blasting Boulder.

hole and tamped firmly, and the charge fired in the usual way. Blockholing requires the most labor of the three methods, but uses the least powder. With the hole properly placed, and of the right depth, a surprisingly small quantity of explosives will accomplish the desired work. The depth of the hole depends upon the character of the rock, a deep hole being required in brittle or tough rock, while a shallow hole can be used in crumbly or easy-splitting rocks.

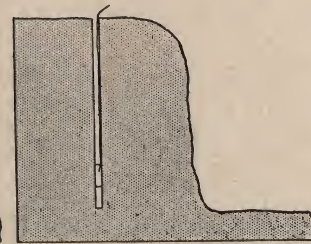
If the boulder is partly embedded, and in such a position that neither mudcapping nor blockholing can be used advantageously, the snakeholing method is employed. A hole, or holes, is dug or punched with a bar beneath the stone, and the charge of explosives placed against its underside, and well tamped. This method requires less dynamite than mudcapping because of the better confinement. The size of the embedded rock and the quantity of explosives to use are determined with more accuracy, and the blast throws the pieces of rock out of the hole, so that handling is facilitated. A light, well-placed charge may be made to roll the rock out of its bed, one of the other methods then being used to break up the boulder.

The quantity and grade of explosives to use in boulder blasting depends upon the character and size of the boulder and the method employed for breaking it. When mudcapping, a fast, high-strength explosive should be employed, such as 50 or 60 per cent. extra ammonia dynamite or straight nitroglycerin dynamite, the latter being better for very hard, tough rocks. Because of the confinement of the charge in snake-holing and blockholing, the quick, smashing blow is not required, and 25 to 40 per cent powders are better for these methods.

Blasting "Through" Cuts.—Hard ground whether clay or rock is loosened in through cuts by blasts loaded in either flat or vertical holes. The selection of the direction of the holes will depend on the nature of the ground. For ground having flat or horizontal



Location of a Flat or Horizontal Bore Hole in Road Cut.



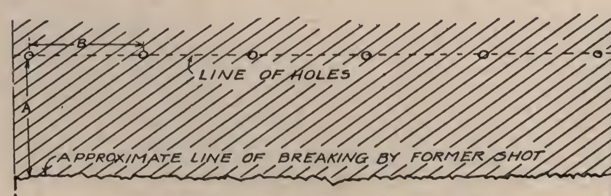
Location of Deep Vertical Bore Hole in Road Cut.

seams the vertical hole is usually preferred; while flat holes are usually best when the seams are vertical or the ground hardest at the top.

When vertical holes are used the best practice is to drill a line of holes all the way across the cut. These should be drilled somewhat below the grade, usually about 1 ft., to insure that no high spots are left between and in front of the bore holes.

These holes usually can be spaced apart in distance from three-quarters to four fifths of their depths for holes less than 6 ft. deep. Deeper holes are usually spaced from one-half to three-fourths of their depth apart.

The burden or distance back from the face must be governed by the resistance of the ground to breaking. This distance usually can be slightly greater than the spacing between the holes.

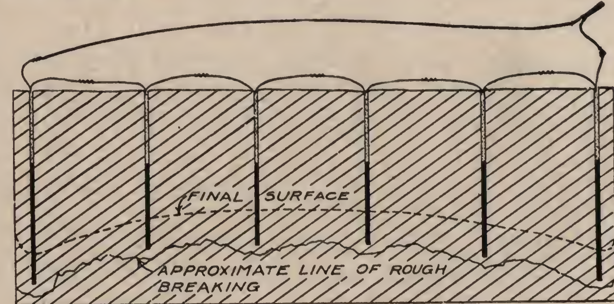


Plan of Approximate Loading for Cut Work.

For shallow cuts the burden "A" is usually slightly greater than the depth of the cut and the spacing "B" is slightly less. For deeper cuts, especially in rock, spacing is usually one-half to three-quarters of depth and the burden about equal to the spacing.

For this blasting electric firing is to be recommended most strongly, as a given amount of explosives in such a load will do more work when all holes are fired together than when fired singly.

The spacing between holes is about the same for flat as for vertical holes, but as a rule, flat holes can be drilled deeper, or in other words a heavier burden can be handled.



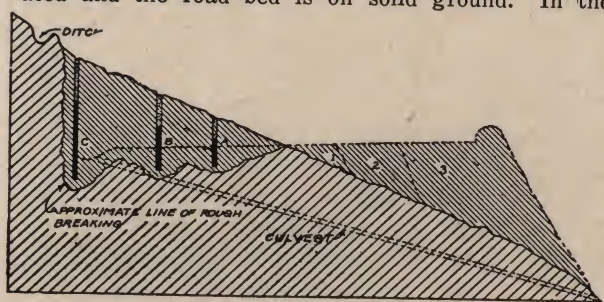
Elevation of Approximate Loading for Cut Work.

To give the proper crown and sufficient depth for the side ditches the holes away from the center are drilled deeper.

The quantity of explosives to use for earth work will depend upon the hardness and character of the ground, the burden on the holes, and the explosive that is used. As a point from which to start, a pound of dynamite for 3 or 4 cu. yds. of material may be used in test shots, and the quantity then varied to meet conditions. A comparatively low-strength explosive should be selected.

The quantity and kind of explosives to use for rock work will be governed by several considerations. The nature of the rock, its relative hardness and toughness and the method of blasting and spacing holes must all be considered. A few test shots will do much to establish the most economical and effective practice. Rock work requires relatively high strength explosive; 30 to 60 per cent dynamite is commonly employed.

Side Hill Cuts.—There are two methods of making these cuts. In one method all of the ground is excavated and the road bed is on solid ground. In the other the cut is not made so wide, but the spoil is used in filling up the lower side to get the desired width.

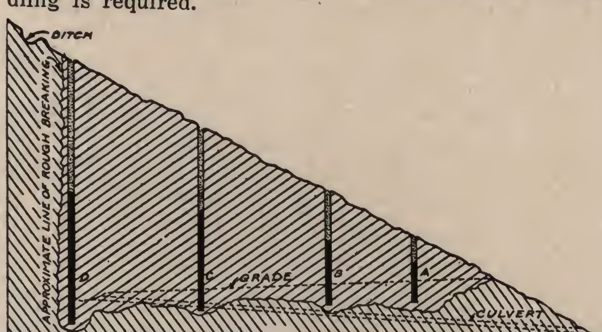


Approximate Method of Loading for Side Hill Cut and Fill.

In earth or clay the side of the cut should be sloping to prevent caving. Another short-hole in the top of the bank will aid in making this slope.

In either case the cut can be worked from the side or the end. Working the full width of the cut from the end is better, especially if the spoil or muck is to be used elsewhere for a fill. This keeps a better cart way open. In working from the end, the general rules laid down for through cuts apply, and the same explosives and loading are recommended.

In working from the side, slight variations are made depending on whether the excavated ground is used again for filling or wasted down the hill. If it is to be used for filling, the loading should be barely heavy enough to break the ground in good condition for handling. When it is to be wasted down the hill, heavy loading will throw it away so that little rehandling is required.



Approximate Method of Loading for Side Hill Cut Where Excavated Material Is to Be Wasted or Hauled Elsewhere.

In earth the side of the cut should be left sloping instead of vertical, to prevent caving.

High Sides.—In highways the removal of high sides, ridges and "thank you marms" of compacted clay or of rock is accomplished by drilling shallow holes and loading them with 20 per cent ammonia dynamite. Such blasts so loosen the ground or rock that it can be moved by means of scrapers and little or no hand labor is required.

Miscellaneous Operations in Road Building.—Digging outfall or discharge ditches is accomplished by blasting in exactly the same manner as for general ditching. Side ditches are blasted in the same way. Light blasts are used to loosen the ground for road machines or hand digging. The blasting of trees, stumps and boulders from both side and outfall ditches is most effective. For the general drainage of the right of way much good can be done by blasting for stream correction. Vertical drainage is frequently effective for draining land-locked basins through which roads must pass. For widening and straightening cuts the loading and explosives used are the same as for side hill cuts. Blasting down gravel and other road surfacing reduces the amount of labor required for loading. Blasting for speeding up steam shovel excavation is effective. The bore holes are spaced about as for other blasting but, unless rock is encountered, are loaded much lighter, the object being simply to blast enough to loosen the material, making the digging easy.

APPROXIMATE NUMBER OF POUNDS OF EXPLOSIVE REQUIRED PER CUBIC YARD ROCK

	Mudcapping Lb.	Snakeholing Lb.	Blockholing Lb.
Sandstone, slate and similar soft or easily broken rock	1	¾	¼
Limestone and other intermediate rock	1¼	1	⅜
Marble, trap, granite and similar hard tough rock	2	1½	½

APPROXIMATE QUANTITY OF EXPLOSIVE REQUIRED TO ROLL OUT BURIED BOULDERS

Diameter Boulder	Cartridge	Diameter Boulder	Cartridge
1½ ft.	½	4 ft.	1½
2½ ft.	¾	5 ft.	2
3 ft.	1		

APPROXIMATE NUMBER OF 1¼x8-IN. CARTRIDGES REQUIRED FOR BLASTING BOULDERS OF VARIOUS SIZE

Greatest Diameter of Boulder, Ft.	Sandstone slate and similar soft, more easily broken rock	Limestone and other intermediate rock	Marble, granite, trap and hard, tough rock
	Mudcapping		
1½	1¼	1½	2½
2	1½	2	3
2½	1¾	2½	3½
3	2	2½-3	4
4	4-5	5-7	
5	7-10		
	Snakeholing		
1½	1	1¼	2
2	1¼	1½	2½
2½	1½	1¼	3
3	1¼	2	3½
4	3-4	4-6	
5	6-7		
	Blockholing		
1½	¼	¼-⅜	½
2	⅜	½	¼
2½	½	½	1
3	½	¼	1
4	1	1¼	2
5	1½	2	8
7	6	8	10

BLASTING LEDGES

The quantity of explosives required for blasting in drilled holes in ledges can be gauged by the table printed above showing the amount to use per cubic yard of rock. Half again as much explosive should be used in a ledge blast as in a boulder. Measure the distance from the open side or face of the ledge back to the drill holes, and compute the number of cubic yards that should be broken off.

E. I. DU PONT DE NEMOURS & CO., INC.

Wilmington, Delaware

Explosives Department

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Boston, Mass.	Kansas City, Mo.	Scranton, Pa.
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Joplin, Mo.	St. Louis, Mo.	

Products: High Explosives, Blasting Powder, Blasting Caps, Electric Blasting Caps, Waterproof Electric Blasting Caps, Electric Squibs, Blasting Machines, Connecting and Leading Wire, Cordeau, Safety Fuse, Cap Crimpers, Tamping Bags, Galvanometers, Rheostats.

All of the du Pont explosives listed here, except Blasting Gelatin, 100% strength, are made on low freezing formulas and are practically non-freezing so far as any temperature in the United States is concerned. This makes it possible to carry on blasting throughout the winter without the hazards involved in thawing explosives.

Economy and Speed in Road Construction through Use of Explosives. The use of explosives frequently increases the speed and economy of road and street construction and for rock excavation explosives are a necessity. The following du Pont explosives and blasting accessories will be found useful for road and street work.

EXPLOSIVES

Red Cross Extra 20-60%. This is an ammonia dynamite which is adapted to a wide variety of work—to quarrying stone for road surfacing, excavating rock, shaking up hard clay in front of the steam shovel, breaking up boulders and removing stumps. Red Cross Extra is less shattering in its action than straight or gelatin dynamite. It is also less water resisting and when it is loaded in wet holes the cartridge wrappers should not be cut or broken and the charge should not be left too long in the water.

Du Pont Extra. This is a low density ammonia dynamite made in eight grades, designated by the letters A to H, which range respectively from 55% to 20% in cartridge strength and from 115 to 172 cartridges, 1¼ in. x 8 in., to the 50 pound case. It is economical for blasting clay, shale and moderately soft rock and for stump and boulder blasting. It has about the same water resistance as Red Cross Extra.

Durox. This is a high explosive of relatively high strength and low density. Where it is not necessary to shatter the rock, Durox gives very satisfactory results.

Quarry Gelatin 25%-75%. This is a gelatin dynamite recently developed expressly for open work and must not be used in tunnels or other close work. It has considerably more shattering power than corresponding grades of regular gelatin dynamite, especially in the 25% and 30% strengths. It is adapted for blasting hard rock and for wet work.

Du Pont Gelatin 20-90%. This is generally known as the standard gelatin dynamite. It is a high density, plastic, water-resisting explosive suitable for blasting hard rock. It is low-freezing and gives off the minimum of fumes.

Du Pont Special Gelatin 35-75%. This is an improved ammonia gelatin. Like our other gelatin dynamites it is dense, plastic, water resistant and low freezing. It gives good execution and the fumes are not objectionable.

Du Pont Blasting Gelatin 100%. This is the strongest explosive made. It is used only where a very quick acting waterproof explosive is required. It is not low-freezing.

Du Pont Straight 15-60%. This is a very quick, powerful and sensitive explosive. It will shatter hard, tough material and resists water well. It is the most satisfactory explosive for mudcapping.

Du Pont R. R. P. This is an explosive of low nitroglycerin content which is midway between blasting powder and dynamite in action. It is used for both rock and earth excavation and especially for stripping. It is also low freezing but resists water poorly. R. R. P. requires a primer of straight dynamite.

Blasting Powder. This explosive is slower in action and much less shattering than dynamite. It is made in seven granulations, the finer granulations being quicker in action than the coarser. The action of blasting powder is of a lifting and heaving nature and very little shattering effect is obtainable. Blasting powder is very susceptible to moisture, but cold weather does not affect it.

BLASTING ACCESSORIES

The cost of explosives and of preparations for blasting demands the use of thoroughly dependable accessories. Du Pont blasting accessories have acquired an enviable reputation for efficiency and reliability.

Electric Detonators. Electric blasting caps, waterproof electric blasting caps and electric squibs are the deto-

Continued on Next Page

nators most frequently used for blasting in road construction. They are made with insulated copper wires ranging from 4 feet to 30 feet in length. The wires of the waterproof electric blasting caps are enamelled to prevent leakage of electricity from the blasting circuit in wet work. Electric blasting caps and waterproof electric blasting caps are furnished in No. 6 and No. 8 sizes. Best results will be secured by using du Pont detonators with du Pont explosives.

Pocket Blasting Machine. This has a capacity of from one to three electric detonators. As the handle is removable, no current can be generated until the handle is placed in position by the shot-firer. This is an important safety feature. If not more than three holes are to be shot, the Pocket Blasting Machine meets every requirement.

Blasting Machine No. 3. This machine will fire 30 electric blasting caps. It weighs 25 pounds. It is compact, thoroughly dependable and easily carried to the point of use.

Blasting Machine No. 3-A. This is a new machine of modern construction, light weight and high capacity. It is rated to fire 50 electric blasting caps with a considerable margin of safety.

Connecting Wire. This is insulated copper wire of No. 20 Brown & Sharpe gauge used for joining the wires of electric blasting caps when they are not long enough to reach between adjoining bore holes.

Leading Wire. This is insulated copper wire of No. 14 Brown & Sharpe gauge for connecting the end wires of the blasting circuit to the blasting machine or power line. It may be either single or duplex, the latter consisting of two strands of single insulated wire bound together with an outside insulation. Duplex wire is not recommended where more than one charge is to be fired at a time.

Cordeau. This is widely used for firing large blasts. It consists of a small lead tube filled with T. N. T. and detonates at the rate of about 17,500 feet per second. It is furnished either plain or countered. Cordeau is fired by means of an electric blasting cap.

Galvanometers and Rheostats. For the detection of breaks in the wiring circuit, short circuits and points of high resistance, the galvanometer is required. It is practically indispensable where electrical blasting is in use. The rheostat is used for testing the capacity of the blasting machine.

Blasting Caps. These are used with safety fuse for firing shots singly or in rapid succession. It is not possible to fire a number of shots simultaneously with blasting caps and fuse. Blasting caps are manufactured in No. 6 and No. 8 sizes.

Safety Fuse. This is necessary for firing blasts with ordinary blasting caps. It is made in various brands, some suitable for dry work, some for damp work and some for wet work.

Cap Crimpers. These are needed for fastening blasting caps to safety fuse. There are two types of du Pont Cap Crimpers, No. 1 and No. 2. The No. 2 Crimper is made with an effective fuse cutting device.

For a complete description of these and other accessories for firing explosive charges, see our Blasting Accessories Catalog. It also illustrates and describes the proper blasting practices. A copy of this book will be mailed to you promptly upon request to our Branch Office nearest you.

HERCULES POWDER COMPANY

(Incorporated)

Wilmington, Delaware

Manufacturers of Explosives and Blasting Supplies

BRANCH OFFICES

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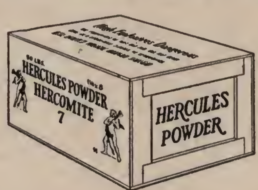
Wilkes-Barre, Pa.

Products: Dynamite, Blasting Gelatin, Blasting Powder, Blasting Caps, Electric Blasting Caps, Waterproof Electric Blasting Caps, Delay Electric Blasting Caps, Electric Igniters, Electric Squibs, Safety Fuse, Cordeau, Leading Wire, Connecting Wire, Blasting Machines, Galvanometers, Rheostats, Cap Crimpers.

Hercomites 2 to 7. This new series of explosives is an achievement in producing explosives for more economical blasting. They represent greater explosive value per dollar than any of our other explosives. All have a weight strength approximating 70%. Different cartridge counts make available cartridge strengths from 20% in Hercomite 7 to 50% in Hercomite 2. Undesirable fumes are reduced to a minimum, making these powders suitable for underground as well as surface work. The number of 1¼″ x 8″ cartridges per 100 lbs. ranges from approximately 240 for Hercomite 2 to 350 for Hercomite 7.

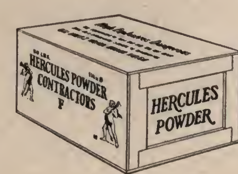


Hercules Extra L. F. Dynamite is made in strengths from 20% to 60%. It is less expensive and safer to handle than straight nitroglycerin dynamite or gelatin dynamite and is adapted for general purpose blasting. Packed in standard cartridges, 50 pounds to the case.

Hercules Gelatin L. F. Hercules Gelatin is good for wet work, or for use where ventilation is poor. Its plasticity enables it to be loaded easily and effectively in holes having an upward slant, and the density and plasticity make it extremely well adapted for tight blasting in hard rock, such as tunnel driving and shaft sinking. It is made in strengths from 25% to 90%, and is packed in standard size cartridges, 50 lbs. to the case.

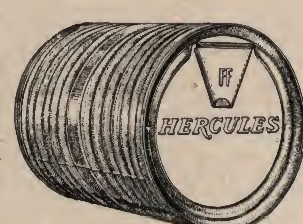
Hercules Gelatin Extra L. F. Dynamite is similar to Hercules Gelatin L. F. in characteristics and in general is used for the same purposes. Its use in place of Gelatin L. F. effects an economy. It is made in 35% to 90% strengths and is packed in standard cartridges, 50 lbs. to the case.

Hercules Contractors' Dynamite. Hercules Contractors' Dynamite belongs to the class of explosives known as granular dynamite. It is best adapted for use in soft seamy material and for large tunnel or "coyote hole" blasts in hard rock. Made in four strengths, F, FF, FFF, FFFF. Packed in standard size cartridges, except F strength, which is packed in paraffine paper bags containing 12½ lbs. The standard case holds a net weight of 50 lbs.



Hercules Straight Nitroglycerin L. F. Dynamite is for use when a quick smashing effect is desired. It produces the best results in mudcapping hard rock and boulders; it is also used extensively for propagated ditch blasts. Hercules Straight Nitroglycerin L. F. dynamite is manufactured in strengths from 15% to 60%.

Blasting Powder is for use in non-gassy coal mines, coal stripping, quarry, and construction work. It is manufactured in different granulations from FFFF (fine) to CCC (coarse). Packed in kegs containing 25 lbs. net.



Herco Powder is a special granulation for Hercoblasting, a method of column loading blasting powder in well-drill holes and firing it with Cordeau-Bickford. Where suited, Hercoblasting reduces explosive costs 30% or more.

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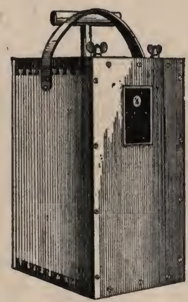
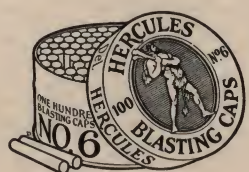


Hercules Blasting Machines. An apparatus for generating electric current used in firing electric blasting caps, squibs, and igniters. We recommend that not more than 50 caps be used in a series circuit. Therefore, we sell no machine larger than Hercules 1-50 hole capacity, although this machine fires more than this number, as it has a large power reserve. Hercules No. 2 machine has a rated capacity of 10 caps.

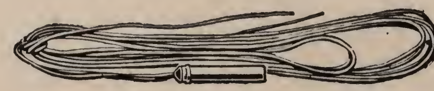
The Hercules Midget Machine is rated to fire up to five electric blasting caps, connected in series, which allows ample power reserve.



Hercules Blasting Caps are used to detonate charges of high explosives. As the efficiency of any high explosive depends on the initial shock, we do not recommend caps weaker than Hercules No. 6. Standard sizes Nos. 6 and 8. Packed 100 in a box, 5 to 50 boxes in a case.

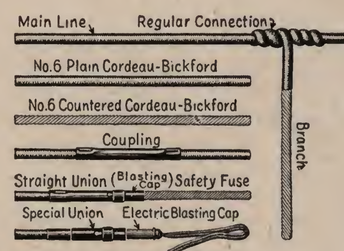
Safety Fuse. We are not manufacturers of safety fuse. We purchase and sell the various standard brands of safety fuse as manufactured in this country. The manufacturers of safety fuse give an estimated burning speed for every brand. Fuse is packed in coils of 100 feet. Cases contain from 5 to 60 coils.

Hercules Electric Blasting Caps are made in two strengths, No. 6 and No. 8, and are provided with insulated copper or iron wires. Enameled copper wires are used for waterproof Electric Blasting Caps. Packed 25 or 50 to the carton, 10 cartons to the case.

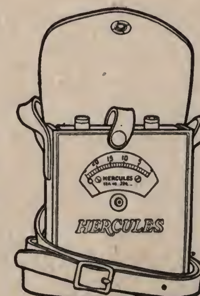


Hercules Electric Squibs are similar in appearance to Electric Blasting Caps and are used to fire charges of blasting powder. Electric squibs are made with copper wires. Packed 25 and 50 to the carton, 10 cartons to the case.

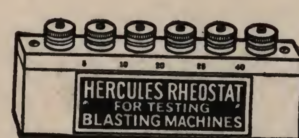
Delay Electric Blasting Caps are designed to fire charges in rotation. They are made in ten different delay periods. Furnished with copper wires. Packed 25 and 50 to a carton, 10 cartons to the case.



Cordeau-Bickford Detonating Fuse. Cordeau-Bickford is a detonating fuse which is widely used in detonating quarry blasts. As Cordeau extends throughout the length of a hole, it detonates almost instantly all parts of the charge. It is the detonator used in Hercoblasting. It is wound on spools containing approximately 500 ft. and is made with plain, countered, or double countered surface. Cordeau-Bickford can be shipped by express.



Galvanometers. A reliable and compact instrument for testing electric blasting circuits, electric blasting caps, and for locating breaks, short circuits, faulty connections, etc. Weight, 1 pound.



Hercules Rheostats. A small instrument offering the easiest and most effective means of testing the strength of a blasting machine without actually firing a series of electric blasting caps. This instrument gives a resistance equal to from 5 to 100 electric blasting caps, with 30 ft. copper wires.

BUCYRUS-ERIE COMPANY

South Milwaukee, Wis. **Erie, Pa.** **Evansville, Ind.**

Power Shovels and Cranes for Road Builders, Draglines, Ditchers, Etc.

Branch Offices: Boston, New York, Philadelphia, Atlanta, Birmingham, Pittsburgh, Buffalo, Detroit, Chicago, St. Louis, Dallas, San Francisco

REPRESENTATIVES

Billings, Mont., Northwest Equip. Co.
Denver, Colo., Herbert Steinbarger Co.
Des Moines, Iowa, Globe Mach. & Supply Co.
Detroit, Mich., Contractors Equip. Co.
Duluth, Minn., Wm. H. Ziegler Co., Inc.
Great Falls, Mont., Northwest Equip. Co., Inc.
Greensboro, N. C., E. F. Craven Co.
Huntington, W. Va., Porter Supply Co.
Jacksonville, Fla., McDonald & Burgman
Kansas City, Mo., Victor L. Phillips Co.
Knoxville, Tenn., R. L. Harris
Little Rock, Ark., Joe Lyons Machinery Co.
Louisville, Ky., Brandeis Mach. & Supply Co.
Los Angeles, Calif., Concrete Mach. & Supply Co.
Miami, Fla., McDonald & Burgman
Minneapolis, Minn., Wm. H. Ziegler Co., Inc.
Montreal, Que., Can., Clare Osborn, Ltd.
Montreal, Que., Can., Mussens Limited
Oklahoma City, Okla., Victor L. Phillips Co.
Portland, Ore., Clyde Equipment Co.
Richmond, Va., Jos. S. Potts Jr. & Co.
Salt Lake City, Utah, National Equip. Co.
San Francisco, Calif., Garfield & Company
Seattle, Wash., Clyde Equipment Co.
Spartanburg, S. C., Standard Mach. & Equip. Co.
Toronto, Ont., Can., Clare Osborn, Ltd.
Toronto, Ont., Can., Mussens Limited
Tulsa, Okla., Victor L. Phillips Co.
Vancouver, B. C., Can, Mussens Limited
Winnipeg, Man., Can., Mussens Limited

Products: POWER SHOVELS, CRANES, DRAGLINES—A COMPLETE LINE: ALL SIZES FROM ½ YD. TO THE LARGEST. ANY KIND OF POWER: GASOLINE, GAS+AIR, DIESEL, ELECTRIC, STEAM, ALSO DREDGES, RAILWAY CRANES, LEVEE MACHINES, SPREADER PLOWS, ETC., ETC.

1-yard Gas+Air BUCYRUS-ERIE Shovel-Crane-Dragline, Type GA2: The fastest gasoline shovel built, and the most powerful—a machine that has produced unequalled output in the 1-yard class.

This remarkably fast shovel has direct-connected engines for crowding and swinging, operating on compressed air that is stored by the main gasoline engine when not hoisting.

This *direct-drive* gives the same cushion effect that the operator has with a steam machine, the same accuracy of control. And, of course, more speed than a friction drive gas shovel, as the crowding and swinging engines are always in gear, ready for instant action—no reversing friction clutches on the hoist, crowd or swing.

In hard digging, the *full power* of the crowding and swinging engines can be used at the same time that the *full power* of the main gasoline engine is exerted for hoisting. Naturally the Gas+Air BUCYRUS-ERIE can dig much harder materials than a single-engine shovel —and has made some remarkable output records in hard digging.

Direct connected engines for crowding and swinging, as well as for hoisting, give the operator of a Gas+Air BUCYRUS-ERIE the positive dipper control necessary for a good job of finish grading. The operator guides the dipper smoothly and accurately with throttle levers, just as with a steam machine. Faster work—and no "gouging" the cut

Continued on Next Page

The original Diesel Shovel—a seasoned machine, thoroughly reliable—1-yard BUCYRUS-ERIE D2: In locations where the high cost of fuel—and the cost of hauling fuel to the job—is a serious problem, the Bucyrus-Erie Diesel has made remarkable savings.

This shovel-crane saves 75% to 90% of the fuel cost of a gasoline shovel handling the same yardage. The Bucyrus-Erie Diesel uses only one-third to one-quarter as much fuel—which costs only one-half to one-third as much per gallon, as gasoline.

We will be glad to send descriptions and working photos of any machine in the complete Bucyrus-Erie line.

Write and tell us the kinds of work you have to do, and we'll send you records made by Bucyrus-Erie machines on the same kind of work—records which show just what you can expect.

A Union of Strength: "Bucyrus" and "Erie"—each the most successful manufacturer in its particular field—consolidated January 1, 1928. The unmatched resources of Bucyrus-Erie assure the buyer of Unequalled Value, More Efficient Machines, Permanence of the Manufacturer, and a More Complete Field Service.

For work in the locations where fuel cost is a problem, the D-2 Diesel BUCYRUS-ERIE gives the finest kind of service—and the lowest possible cost-per-yard. It operates on fuel oil that costs only ⅓ to ¼ as much as gasoline, and uses far less; the fuel cost is usually 75% to 90% lower. The BUCYRUS-ERIE Diesel is the original Diesel shovel, perfected by years of experience. It is simple and reliable—powerfully built to stand hard service

Working in isolated places, contractors have in many cases been able to cut ⅓ to ½ from their total costs by using a Bucyrus-Erie Diesel.

This machine is a development of the first Diesel Shovel built—highly perfected by years of field service. It is the simplest of Diesel Shovels, with fewer gears—and in fact fewer parts throughout.

The engine, a Bucyrus-Erie Atlas—is unequalled for reliability. Starts instantly, and goes from stone-cold to full power in 20 seconds—and no priming.

1-yard BUCYRUS-ERIE Steam Shovel-Crane, Type B-2: The most popular shovel-crane ever built—more than 4,500 in service.

Noted for large output, and an exceptionally wide margin of Reliability. Hundreds of contractors have learned to depend on their B-2 Bucyrus-Eries in rock work the same as in clay or gravel.

An unique manufacturing experience, gained in building thousands of machines of the same type, has developed hundreds of improvements all over this machine—refinements in details, which have made the operation faster and smoother.

The B-2 is built with extra power for hard digging—and the rugged strength to stand such work continuously. Write for records of output and upkeep cost.

B-2 Steam BUCYRUS-ERIE operating as a crane with clamshell bucket, unloading cars and handling concrete road aggregates to loading bins. All the smaller sizes of BUCYRUS-ERIES—and many of the larger sizes—can be quickly changed over for service as crane or dragline as well as shovel, giving the use of three machines at little more than the cost of one

HARNISCHFEGER CORPORATION

Established 1884

3885 National Ave., Milwaukee, Wis.

Shovels and Excavating Machinery

BRANCH OFFICES:

Atlanta, Ga., 1050 Ponce de Leon Apts.
Baltimore, Md., 1302 Lexington Bldg.
Birmingham, Ala., 401 Pioneer Bldg.
Boston, Mass., 194 Boylston St.
Charlotte, N. C., 1101 Johnston Bldg.
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Memphis, Tenn., 267 Union Ave.
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New York, N. Y., 50 Church Street
Philadelphia, Pa., 5102 Lancaster Ave.
Pittsburgh, Pa., Farmers Bank Bldg.
Portland, Ore., 80 4th Street
St. Louis, Mo., 524 Buder Bldg.
San Francisco, Cal., 32 Beale Street
Seattle, Wash., 534 First Ave. South

AGENTS FOR P&H PRODUCTS

Denver, Colo.—Paul Fitzgerald..........................U. S. Nat'l Bank Bldg.
Salt Lake City, Utah—Landes & Co...........246 W. South Temple St.
Phoenix, Ariz.—Arizona Tractor & Equip. Co, 238 W. Jefferson St.

Warehouse and Service Stations: Philadelphia Jacksonville Memphis Seattle Los Angeles San Francisco

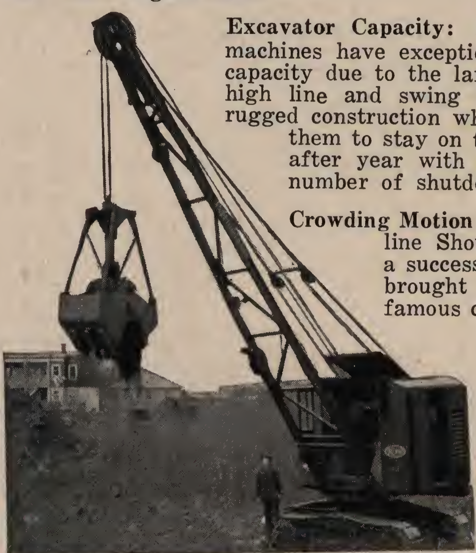
Products: Gasoline, Electric and Diesel Shovels, Draglines, Clamshells, Cranes, Skimmer Scoops, Pile Drivers, Backfillers; Wheel or Ladder Type Trenchers; Contractors' Hoists; Electric Cranes and Hoists; Truck and Trailer Cranes.

The equipment listed above are the products of a company having more than forty years' experience in the manufacture of heavy duty machinery.

The machines are built entirely in the P & H shops and every one is backed by the skill and services of the entire organization.

Excavator Capacity: All P & H machines have exceptionally large capacity due to the large engines, high line and swing speeds, and rugged construction which permits them to stay on the job year after year with a minimum number of shutdowns.

Crowding Motion: The Gasoline Shovel was not a success until P & H brought out the famous chain crowding motion which has many advantages; among which are the following: It is positive, will force the dipper above the boom point and is entirely independent of the hoisting motion. For this reason the P & H can cut a level floor or cut slopes accurately. There are no complicated air or steam engines connected with the P & H Crowd, and no cables which require frequent replacement. A cable crowd is a continuous expense not only because of the cost of the cable itself but because of the time lost in reeving.



P & H Model 300 Clamshell. Easily converted for use as dragline, backfiller, shovel, or with magnet, etc.

Main Features of P & H Standard Line

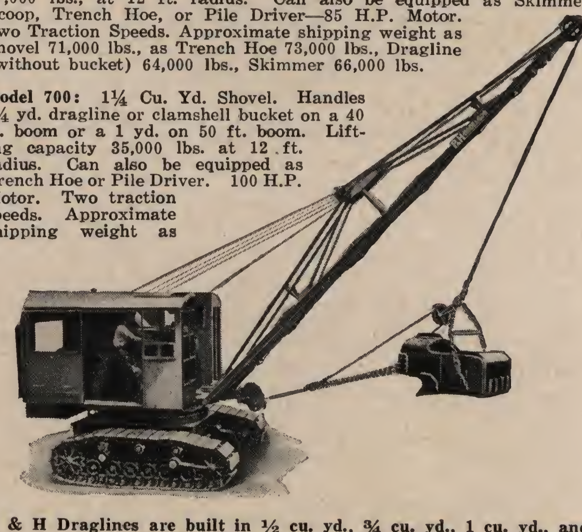
1. Conservatively rated—long life.
2. Unit Cast Steel Construction—Great Rigidity and Strength.
3. Heat treated and alloy steels used.
4. All understructure bearings bronze bushed.
5. Short Tail Swing—Works in limited clearances.
6. Power Clutch Control—Ease of operation.
7. Large Size Motors—Fast line and swing speeds—Large capacity.
8. Powerful independent crowding motion—Patented.
9. Two speed traction—Goes anywhere.
10. Real interchangeability—Into shovel, drag, clam, crane, skimmer, hoe, pile driver, by means of P & H Patented drum spider, without changing drums.
11. Shipped without dismantling.
12. Backed by real service.

Model 400: ¾ Cu. Yd. Shovel. Handles ¾ yd. dragline or clamshell bucket on a 35 ft. boom or ½ yd. on 40 ft. boom. Lifting capacity 18,000 lbs. at 12 ft. radius. Can also be equipped as Skimmer Scoop, Trench Hoe or Pile Driver. 55 H.P. Motor. Two traction speeds. Approximate shipping weight as Shovel 53,200 lbs., as Trench Hoe 53,000 lbs., Dragline (without bucket) 48,000 lbs., Skimmer 50,500 lbs.

P & H Shovel with fully enclosed cab. Made in ½ yd., ¾ yd., ⅞ yd., 1 yd. and 1¼ yd. capacities. Easy change of boom allows use of clamshell, dragline, orange-peel bucket, backfiller, skimmer scoop, crane hook, magnet

Model 600: 1 Cu. Yd. Shovel. Handles 1 yd. dragline or clamshell bucket on a 40 ft. boom, or ¾ yd., on 50 ft. boom. Lifting capacity 27,000 lbs., at 12 ft. radius. Can also be equipped as Skimmer Scoop, Trench Hoe, or Pile Driver—85 H.P. Motor. Two Traction Speeds. Approximate shipping weight as Shovel 71,000 lbs., as Trench Hoe 73,000 lbs., Dragline (without bucket) 64,000 lbs., Skimmer 66,000 lbs.

Model 700: 1¼ Cu. Yd. Shovel. Handles 1¼ yd. dragline or clamshell bucket on a 40 ft. boom or a 1 yd. on 50 ft. boom. Lifting capacity 35,000 lbs. at 12 ft. radius. Can also be equipped as Trench Hoe or Pile Driver. 100 H.P. Motor. Two traction speeds. Approximate shipping weight as Shovel 90,000 lbs., as Trench Hoe 90,000 lbs., Dragline (without bucket) 80,400 lbs.



P & H Draglines are built in ½ cu. yd., ¾ cu. yd., 1 cu. yd., and 1¼ cu. yd. sizes

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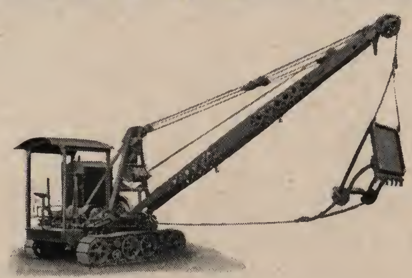
Model 206 B: Handles 1 cu. yd. clamshell bucket on a 40 ft. boom, ⅞ cu. yd. shovel dipper, and has a lifting capacity of 22,000 lbs. at 12-ft. radius. Can also be equipped as dragline, trench-hoe, skimmer and pile driver. Approximate shipping wt. as Shovel 55,800 lbs., Trench Hoe 55,000 lbs., Dragline (without bucket) 48,500 lbs., Skimmer-Scoop 51,700 lbs.

P & H Ground Hog Model 300: The P & H "Ground Hog" was designed to meet the need for a fast and sturdy, full revolving ½ cu. yd. excavator and crane. This machine was tried out in actual service for nearly 2 years before being placed on the market and it has demonstrated beyond any doubt that it is a reliable piece of equipment.

Like the larger P & H machines it can be equipped as shovel, dragline, clamshell, crane, pile driver, skimmer, trench hoe, etc.

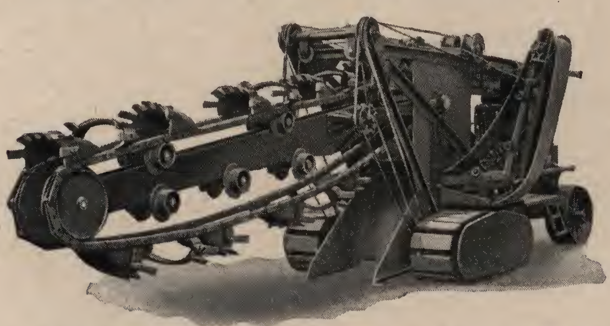
It handles a ½ yd. dipper or a ½ yd. dragline bucket on a 30 ft. boom; or ½ yd. clamshell bucket on a 35 ft. boom. Lifting capacity 11,400 lbs. at 12 ft. radius: 50 H.P. Motor. Approximate shipping weight, as shovel 42,700 lbs., as clamshell 37,000 lbs., without bucket.



P & H Model 35 Backfiller. Boom adjustment between 22 and 31 ft., 35 H.P. Motor

P & H Trenchers: Model 10-30 cuts up to 13 ft. deep and from 22 to 35 in. wide. Digging feeds 8 inches to 10 feet per minute. 1, 1¼ and 1½ miles per hour road speed. 55 H.P. Motor. Weight 42,500 lbs.

Model 15-36 cuts up to 15 ft. deep and from 22 in. to 42 in. wide. Digging feeds 8 inches to 10 feet per minute. 1, 1¼ and 1½ miles per hour road speed. 80 H.P. Motor. Weight 53,000 lbs.

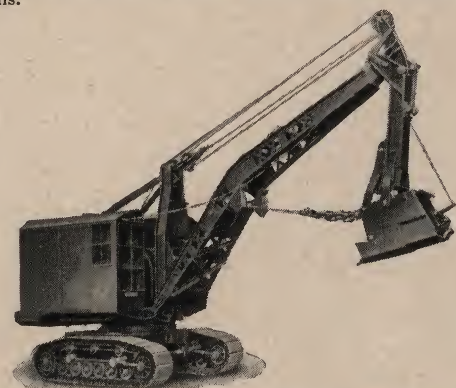


P & H Ladder Type Trencher. Model 10-30 cuts trench 13 ft. deep and up to 35 in. wide. Model 15-36 cuts trench 15 ft. deep and up to 42 in. wide

Strongly built structural steel car body, with three-point suspension —unit cast steel frame and unit steel construction throughout. Four-cylinder heavy duty engine. All gears of steel and enclosed in steel casing, providing a real safety factor. All main gears grouped in single housing on short shafts placed in same plane. Any one shaft can be removed without disturbing the rest.

P & H Skimmer Scoop. Especially useful for shallow grading or ripping up old pavements. Used on P & H Models 400 and 600

Dual control permits operation from either side of trencher. Platform on both sides allows operator to always keep work in sight. All operating levers grouped within easy reach of operator. The ONLY large trenching machine with Three Bucket Speeds, without change of sprockets, achieving best results in varying soil conditions. Spoil conveyor arranged to discharge at either side of machine—adjustable to desired height. Safety slip clutch at point of shock. Has three high traction speeds. Operates in restricted places because of its narrow width. Cuts accurately to grade, an important feature in sewer and drainage work. Powerful crowding action which can be detached when not needed, permits cutting through hard soils.



P&H Trench Hoe Booms can be mounted on all P&H full revolving corduroy machines. The 1 and 1¼ yd. sizes can dig from 20 to 24 ft. deep, depending on soil conditions.

The P & H Model 35-Backfiller is built on a unit cast steel foundation which assures permanent alignment.

It is of high grade workmanship throughout and is extremely accessible for lubrication and adjustments. There are only 4 operating levers and these have a straight forward and back motion, making operation very simple. All reversing motions are controlled through friction clutches.

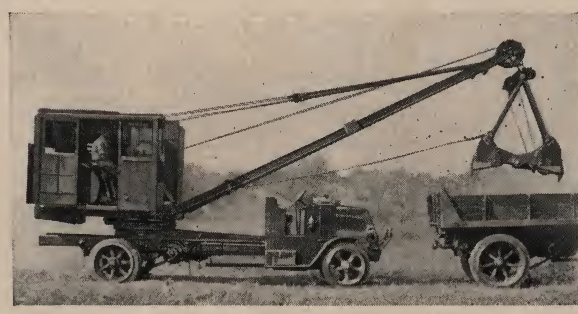
The engine and gas tank are completely enclosed and a canopy is placed over the operator's seat and the main machinery.

The boom is adjustable between 22 and 31 ft. in steps of 18 inches and can be changed in a few minutes. 35 H.P. Motor. Hoist line speed, 300 ft. per minute; dragline speed 150 ft. per minute and travel speed 1½ miles per hour.

As a crane the machine handles 2,000 lbs. at 15 feet radius.

Weight 13,800 lbs. Send for special backfiller bulletin.

P & H Truck and Trailer Cranes: Can be mounted on chassis of practically any suitable make of 5 or 7½ ton truck or trailer. Furnished complete with truck or trailer if desired or can be mounted on corduroy traction when the job requires it. Travels quickly from job to job.



P & H Truck Crane. Mounted on standard Truck Chassis. Does work of 20 to 30 men

THE MARION STEAM SHOVEL COMPANY

Established 1884

Marion, Ohio

Manufacturers of Shovels, Cranes and Draglines

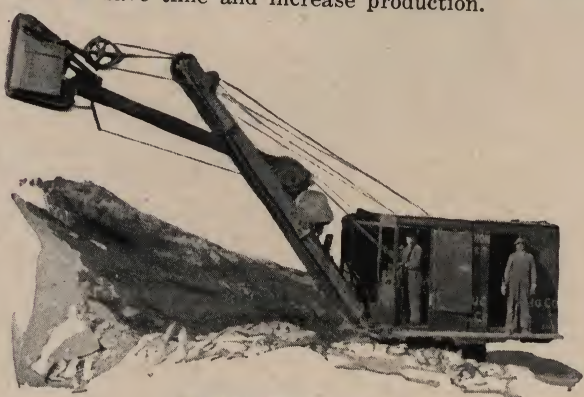
DISTRICT OFFICES

Birmingham, Ala., 510 Martin Building
Chicago, Ill., 1442-43 Monadnock Block
Dallas, Tex., 1310 Kirby Building
Kansas City, Mo., 1231 Woodswether Road

New York, N. Y., Room 2083, 50 Church Street
Philadelphia, Pa., 31st and Chestnut Streets
Portland, Ore., 54 4th Street
San Francisco, Cal., 571 Howard Street

Products: STEAM, GAS-ELECTRIC, ELECTRIC, STRAIGHT GAS, AND DIESEL SHOVELS, DRAGLINES, CRANES, CLAMSHELLS.

Marion Type 7 Gas-Electric Shovel, Dragline, Crane: With the type 7 you get a cubic yard each dip at no reduction in speed, no increase in maintenance cost, no addition to the working crew, over the ¾ yard machine. Type 7 will go anywhere a ¾ yard shovel will go; it will do anything the smaller machine will do, and more —it will save time and increase production.

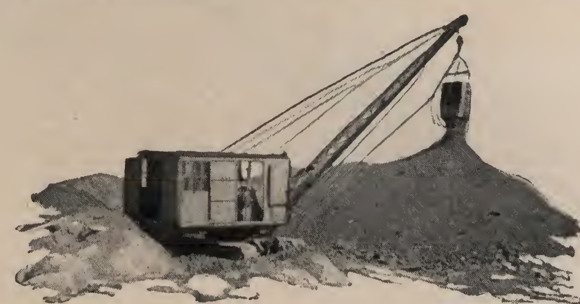


RELATIVE FEATURES

	¾-yd. shovel	1-yd. shovel
Crew	1 man	1 man
Dipper capacity	¾-yd.	1-yd.
Capacity per hour, cubic yards	30-60	40-80
Maximum bail pull	15,700	17,500
Length of boom	17′6″	20′0″
Length dipper handle	12′6″	15′0″
Radius rear end of cab	9′6″	10′0″
Height cab above grade	12′6″	11′8″

Outstanding Improvements Which Give Lower Operating Costs and Bigger Profits with Type 7 Gas-Electric:

1—1 cubic yard dipper—an honest load at every dip.
2—Brass bushings throughout.
3—Heavy duty mill type motors—practically indestructible.
4—Independent drive for each motion—no clutches to cause trouble or get out of adjustment.
5—Crawler of new design that gives you more power, greater speed and extreme mobility.
6—Self-cleaning propelling gears for the crawlers. Rocks, sticks, sod, etc., cannot clog or foul the crawlers to cause delay and cut your profits.
7—Your operators will like the steering, which is completely under their control from the seat in the cab.
8—Gantry frame of new design which completely eliminates reversal of stresses of the rotating frame I-beams.
9—Protective devices arranged to regulate current when crowding motion encounters extreme overloads.
10—Engine proportions combined with generator characteristics prevent stalling of engine under load.
11—Rapid booming up under full load is made practical by a specially designed boom hoist completely enclosed and running in oil.
12—Drooping voltage generator combined with series motors approximates flexible characteristics of steam machine.
13—Hoisting machinery designed and built as a compact and heavy duty unit.
14—A new tripping device that acts with each digging cycle makes dumping easy and certain.
15—The new Marion patented dipper handle spacer positively prevents spreading of dipper handle.
16—All-steel cab; roomy and well-lighted; built strong and light.
17—Comfort and efficiency for the operator—large spring seat; smooth, easy lever action; metal locker for clothes, etc.; easy tripping device; and many other conveniences.
18—The inside type of dipper handle with patented spacer is far superior to any other construction now in use.
19—Lower cable expense assured by the use of the triple hitch and high ratio between drum and rope diameters.
20—Shovel, Dragline or Crane—Crane, Dragline or shovel—any way you want to use the Type 7, it is completely convertible without mechanical complications.



	Shovel	Dragline	Clamshell
Capacity of dipper	1 cu. yd.	¾ cu. yd.	¾ cu. yd.
Length of boom	20′0″	40′0″	40′0″
Length of dipper handle	15′0″	....	....
Rating of hoist motor (60 min.)	20 H. P.	20 H. P.	20 H. P.
Rating of swing motor (60 min.)	9 H. P.	9 H. P.	9 H. P.
Rating of crowd motor (60 min.)	9 H. P.	....	....
Rating of generator (continuous)	25 K. W.	25 K. W.	25 K. W.
Brake horsepower of engine	85	85	85
Capacity of fuel tank, gallons	50	50	50
Hoisting cable	⅝″	⅝″	⅝″
Drag cable	....	¾″	....
Boom hoist cable	⅝″	⅝″	⅝″
Approximate shipping weight	69,000	65,000	65,000

Marion Types 7 and 440 One Yard Shovels, Clamshells, Draglines —Steam, Gas-Electric, Electric, Straight Gas, Diesel: The complete line of Type 7 and 440 shovels, clamshells and draglines has established an entirely new and advanced standard of speed, power and permanence in excavator design. Built oversize throughout to endure the hardest service, the number of working parts are reduced and many new and exclusive profit-making features are added. With only the slight modification required to adapt Types 7 and 440 to any kind of power, Marion has produced the only complete line of shovels, clamshells and draglines ever introduced in steam, gas-electric, electric, straight gasoline and Diesel power.

By having a complete line, in order to fill all needs, Marion can recommend the right machine for the right job.

Type 7 Steam: The only machine of its capacity with Marshall Valve Gear, which increases steam efficiency 20 per cent and decreases coal and water consumption 25 per cent. The only machine with splash lubricated

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swinging engines for positive oiling to save labor and repairs. Where coal and water are of good quality, inexpensive and easy to obtain, and where smoke is not objectionable, this machine has no equal.

Type 7 Gas-Electric: Independent drive for each of the major movements—hoisting, swinging and crowding—insures delivery of maximum power for fast and accurate work. Operates by electric power generated by a direct-connected, 85 horsepower, 6 cylinder gasoline engine. Needs only one man to operate. Is the only Gas-Electric machine on the market. Takes the place of a steam machine where it is not practical to use steam.

Type 7 Electric: No fumes, smoke or dirt. Requires only one man to operate. Extremely low operating and maintenance costs. Direct drive for hoisting and swinging. Motor generator set for operating on AC supply line. Direct current motors with high torque at the slow speeds and low torque at the high speeds. Drooping voltage generator gives flexibility of steam machine. No excessive load peaks on transmission line.

Type 440 Straight Gas: Exceptionally fast, smooth running and mobile and requires only one man to operate. Many new features, including Morse Silent Chain, Dot Pressure Lubrication and Brass Bushed Bearings. One piece cast steel lower frame and enclosed type crawlers. Marion Powerset Control for easy and smooth operation. Same general construction as Steam, Gas-Electric and Electric Types.

Type 440 Diesel: Low fuel costs. Besides its lower initial per gallon cost, fuel oil goes twice as far, in quantity, as gasoline. This reduces frequency of replenishing supply and reduces fuel transportation problems. No carburetor to adjust, no spark plugs and no ignition system. Otherwise, same machinery and operating equipment as in the straight Gas machine. Requires only one man to operate.

Special Points on the New Marion 440 Straight Gas and Diesel Shovels, Draglines, Cranes: A smooth running, powerful and lasting one-yard shovel—Marion's newest engineering achievement. With the perfection of outside band clutches—oversize and almost indestructible, Marion introduces a practical one-yard shovel with power and speed in the crowd, hoist and swing motions —a shovel free from vibration and capable of withstanding the hardest digging for years longer than any other make.

Power-set clutches for the hoist and swing motions—simple in construction and easy to operate.

Gantry frame pin connected in all places—back legs attached to main casting, thereby relieving the I-beams of digging strains.

Unit machinery construction —engine and power take-off, main reverse and swing clutches and hoist machinery —with flexible connections between each unit.

Other Features: Complete control of all operations, including propulsion and steering, centered in levers and foot pedals at operator's position.

Provided with Hercules four-cylinder, 75 horsepower, heavy duty industrial type engine, mounted on three-point support and so perfectly balanced that vibration is eliminated.

Performance: Actual field tests of the most severe nature in all kinds of work have proved the New Marion 440 the first gasoline or Diesel shovel of its size to meet the rigid standards which mark Marion as the leader in the industry.

440 Diesel is operated by Foos two-cylinder Diesel engine—so perfectly balanced that all vibration is eliminated—an unique feature for a Diesel driven excavator. The true economies of oil for fuel may now be realized.

Abridged Specifications and Working Ranges Types 7 and 440 Draglines

Type of Power	7 Steam		7 Electric		7 Gas-Electric		440 Straight Gas		440 Diesel	
Capacity of bucket	¾ cu. yd.		¾ cu. yd.		¾ cu. yd.		1 cu. yd.		1 cu. yd.	
Length of boom	40-ft.		40-ft.		40-ft.		40-ft.		40-ft.	
Width of cab	9′ 6″		9′ 6″		9′ 6″		9′ 6″		9′ 6″	
Clearance radius rear of cab	10′ 0″		10′ 0″		10′ 0″		10′ 0″		11′ 9″	
Height of cab above grade	11′ 8″*		11′ 8″		11′ 8″		11′ 8″		11′ 8″	
Width crawling traction belt	1′ 10″		1′ 10″		1′ 10″		1′ 10″		1′ 10″	
Width over crawling traction trucks	9′ 6″		9′ 6″		9′ 6″		9′ 6″		9′ 6″	
Length bearing one crawler truck	9′ 6″		9′ 6″		9′ 6″		9′ 6″		9′ 6″	
Total bearing area, two belts, approximate	35 sq. ft.		35 sq. ft.		35 sq. ft.		35 sq. ft.		35 sq. ft.	
Approximate shipping weight	61,000 lbs.		65,000 lbs.		65,000 lbs.		60,000 lbs.		60,000 lbs.	
Diameter hoisting cable	⅝″		⅝″		⅝″		⅝″		⅝″	
Diameter drag cable	¾″		¾″		¾″		¾″		¾″	
Diameter boom hoist cable	⅝″		⅝″		⅝″		⅝″		⅝″	
Angle of boom	25°	40°	25°	40°	25°	40°	25°	40°	25°	40°
Height of dump above grade	9′ 3″	18′ 0″	9′ 3″	18′ 0″	9′ 3″	18′ 0″	9′ 3″	18′ 0″	9′ 3″	18′ 0″
Radius of dump	40′ 0″	34′ 4″	40′ 0″	34′ 4″	40′ 0″	34′ 4″	40′ 0″	34′ 4″	40′ 0″	34′ 4″
Depth of cut below grade	18′ 0″	10′ 4″	18′ 0″	10′ 4″	18′ 0″	10′ 4″	17′ 0″	9′ 4″	17′ 0″	9′ 4″
Maximum height of boom above grade	22′ 0″	30′ 10″	22′ 0″	30′ 10″	22′ 0″	30′ 10″	22′ 0″	30′ 10″	22′ 0″	30′ 10″
Maximum clearance radius of boom	41′ 0″	35′ 3″	41′ 0″	35′ 3″	41′ 0″	35′ 3″	41′ 0″	35′ 3″	41′ 0″	35′ 3″

THE BAY CITY DREDGE WORKS

Home Office: Bay City, Mich. Eastern Office: 302 Broadway, New York

Convertible Power Shovels—Dredges—Tractor Shovels

REPRESENTATIVES

Boston, Mass., Thos. D. Connolly, No. 1 Court St.
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Chicago, Ill., G. F. Lowe Co., 612 N. Michigan Ave.
Detroit, Mich., M. A. Derr, 6331 Tireman Ave.
Los Angeles, Calif., L. M. Railsback, 115 S. Los Angeles St.
Philadelphia, Pa., De Huff & Hopkins, Morris Bldg.
Pittsburgh, Pa., M. J. O'Brien Co., Union Bank Bldg.
St. Paul, Minn., Heil H. W. Sales Co., 2651 University Ave.

AND OTHERS IN PRINCIPAL CITIES.

Products: 16-B CONVERTIBLE EXCAVATOR, LAND DREDGES, BAY CITY CONVERTIBLE TRACTOR SHOVEL (McCORMICK-DEERING), FULL CIRCLE SHOVELS.

Model 16-B Convertible Excavator: The 16-B with its five convertible buckets is adapted for a wide range of work. With Skimmer Bucket it has no equal for road or pavement excavation or shallow cutting of any sort. The skimmer fills on every trip and leaves a smooth grade. Cuts swath 34 ft. wide. Full crawler mounting. ¾ yd. buckets. A "better" machine for heavy work.

Built entirely of steel, with Zerk-Alemite lubrication. Designed to stand up under hardest work. Also equipped with ¾ Yd. Shovel (not illustrated) for high bank work. Loads on railroad car without dismantling. Operator in front with clear, unobstructed view of work. All machinery easily accessible. Write for catalog.

For Hard Trenching. Trench Buckets 18″ to 48″ Wide.

Also Furnished with 30-35 or 40′ Crane Booms

Tractor Shovel: A fast, economical one-man operated Convertible Power Shovel for small jobs. International Tractor. Full crawler mounting. Operates ⅜ Yd. Buckets. Built of special materials for high-speed work.

Operates Shovel, Clamshell, Dragline, Trench Scoop, Backfiller, Crane.

An unbelievably fast one-man machine that will travel anywhere and do the work that a big shovel cannot afford to handle. Full crawler mounting. 5 dips per minute.

Lots of Speed, Power, Endurance for Digging, Stripping, Loading, General Excavating, House Basements, Backfilling, Material Handling, Stock Piling, Road Maintenance.

Shipped Completely Assembled. Tractor Service by International Harvester Branches.

Trenching for Water Line at 500 Ft. Per 9 Hours

The Fastest Moving and Operating Machine on the Market. Quickly Converted

Specifications: Tractor Shovel. **Weight:** 9¾ tons. **Booms:** For Shovel, 15′. For Crane, 25′. Backfiller, 25-35′. **Dumping Radius:** Shovel, 16′. Crane, 20′. **Crawlers:** 10′ long. Bearing Pressure, 6 lbs. per sq. in. **Three Speeds:** Highest, 4 mi. per hr. **Width:** 8′ 0″. "E-Z" Lever Control. **Length:** 13′ 6″. 270° Swing.

All Machinery No Counter-weight

TIMKEN BEARING EQUIPPED

Machine Cut Gears Forged and Tempered

KEYSTONE DRILLER COMPANY

Cable Address
"Driller"

Beaver Falls, Pa.

Manufacturers of Excavators

BRANCH OFFICES: **New York, N. Y.** 170 Broadway. **Chicago, Ill.** Monadnock Block. **Joplin, Mo.**

AGENTS

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Worcester, Mass. George R. Conyne, 123 Stafford St.
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Columbus, Ohio. Consolidated Eq. Co., 206 Clinton Bldg.
Grand Rapids, Mich. F. D. Lake Co., 16 Campau Ave., N. W.
Joplin, Mo. Keystone Driller Co.
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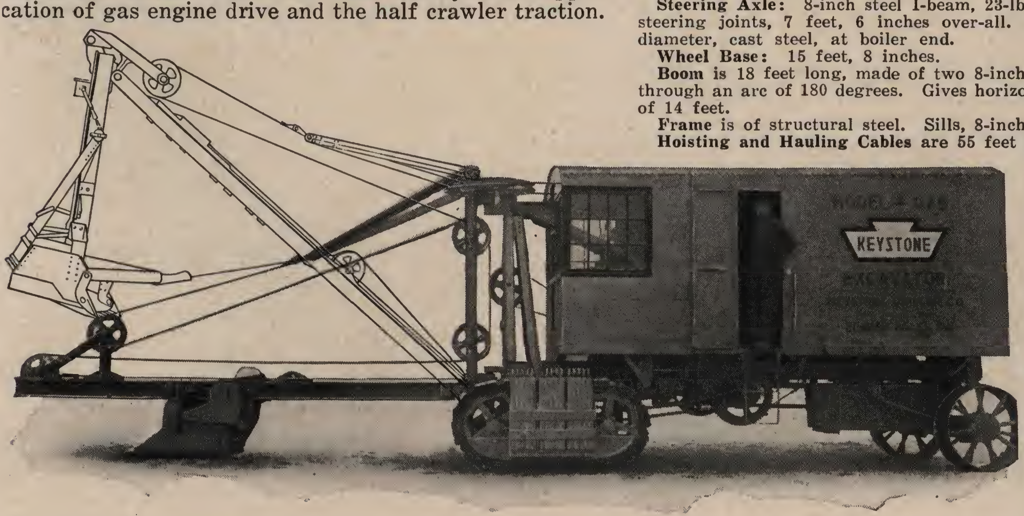
Well Drills and Excavators
TRADE MARK
KEYSTONE
REGISTERED U. S. PATENT OFFICE
Keystone Driller Co., Beaver Falls, Pa.

Products: EXCAVATORS.
Also Well Drills and Pumps.

The Keystone Excavator is the Skimmer-Pullscoop power shovel. It is comparatively light, low priced and is exceptionally portable and versatile. Powered with a four cylinder gas engine developing 57 H. P. at 800 R. P. M. it has an abundance of reserve power for heavy duty in hard digging. In digging the machine itself does not revolve; but the 18 ft. boom swings through an arc of 180 degrees. It is mounted on half caterpillars, the crawlers being carried upon a 6-inch steel axle under the boom fulcrum, or digging end of the machine. Equipped with four readily interchangeable scoops, Skimmer, Ditcher, Dipper and Clam, it is adaptable to a wide range of uses. Its proper and hardly disputed fields are, however, (1) shallow street and road excavation with the Skimmer and, (2) ditching, all widths and depths to 20 feet, with the Pull-Stroke ditcher.

New Model 4-Front Crawler. The new Model 4 is the result of years of experience in the manufacture of the lighter and more portable type of excavating shovel. It weighs 17 tons, which is not excessive for a modern road or ditching unit. The wheelbase is 15 ft. 8 in., which effects a desirable distribution of weight and increases stability. A half-length crawler, or caterpillar traction, of approved design is mounted under the boom fulcrum, where the greatest strains, weights and stresses are centered. This machine has surprising tractionability. It will negotiate any passable road in low speed and under more favorable conditions will go ten or fifteen miles per day. The half-circle swing offers certain advantages in rigidity and economy of operation. It also lends itself most readily to the application of gas engine drive and the half crawler traction.



Skimmer Bucket. The skimmer bucket is a heavy and effective scoop of 5/8 cu. yd. capacity, carried on six chilled rolls, with a dropping bottom, hinged at the toothed end. Because of its 14 ft. horizontal crowd there is no machine like it for shallow repaving jobs, tearing up old concrete, macadam, paving blocks, etc. It is also especially well adapted for heavy highway cutting. In cuts 15 and 20 feet deep the skimmer bucket will fill the trucks with 40 yards or more per hour. The bucket overcuts the boom and hence will notch a bank at any height. It will dig in shale, soapstone or soft rock without blasting. Another economy lies in the fact that it eliminates most hand trimming, leaving the street or road finished to grade, ready for the road base.

Pull-Stroke Ditcher. The Pull-Stroke ditcher also has a bottom hinged at the toothed end, which swings free in dumping. The bucket is self-cleaning, so that even the narrowest bucket, 8 in., can be operated in gumbo and sticky clay. 11 sizes, up to 68", are manufactured, all usable on the same machine with the same set of attachments. The 26" and 32" buckets are most commonly used for ditching and cellar digging. In digging cellars or ditches the machine stands always on the solid ground, is never taken into the pit. Will also handle a 1/2 yd. clamshell. The Skimmer and Pull-Stroke ditcher are fully covered by patents issued and pending.

Model 4—Front Crawler Gas Drive—17 Tons

CODE WORD—EXAFRY

SPECIFICATIONS

Engine: Climax four-cylinder, Model TU, 5½x7 inches. Develops 57 H. P. at 800 R. P. M., the normal operating speed. Has reversing jack shaft transmission with twin disk clutch.

Gas Tank over engine holds 60 gallons.

Traction: The crawlers, or apron wheels are 40 inches high, 22 inches across tread and 4 feet long on the ground; 7 feet, 4 inches long over-all.

Traction Speeds: One mile and two and three-quarter miles per hour.

Front Axle: Crawler mounting at boom pivot end of machine, 6-inch diameter axle steel. Length over-all, 9 feet, 10½ inches.

Steering Wheels: 36-inch diameter, 5/8-inch tire 16 inches wide with removable cutter bands, at boiler end.

Steering Axle: 8-inch steel I-beam, 23-lb. with auto-type knuckle steering joints, 7 feet, 6 inches over-all. Spindles, 3¼ inches in diameter, cast steel, at boiler end.

Wheel Base: 15 feet, 8 inches.

Boom is 18 feet long, made of two 8-inch 18-lb. I-beams. Swings through an arc of 180 degrees. Gives horizontal crowding movement of 14 feet.

Frame is of structural steel. Sills, 8-inch, 25-lb. I-beam.

Hoisting and Hauling Cables are 55 feet long; 5/8-inch by 3/4-inch armored steel.

Lubrication: Alemite system and grease cups.

Boom Swing has improved composition friction cones.

Weight: 17 tons. **Length** over-all, except boom, 24 feet, 7 inches. **Height** over-all, 11 feet, 7 inches. **Width** over-all, 10 feet.

Scoops and Buckets: The machine is equipped, as specified, with three styles of scoops, improved 5/8-yard **Six-Roll Skimmer** with cylindrical rolls, **Drop-Bottom Ditcher,** and **half-yard Clamshell.**

MEAD-MORRISON MANUFACTURING COMPANY

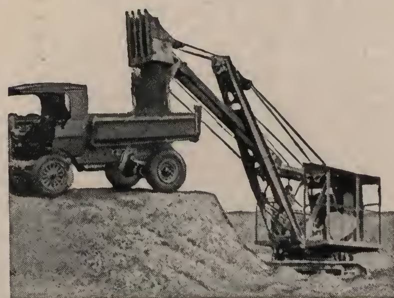
457 Prescott Street, Boston, Mass.

Pioneer Manufacturers of Hoisting, Hauling and Handling Machinery

Factory in Canada at Welland, Ontario. Branch Offices: New York, Montreal, Chicago

Products: HALF YARD SHOVEL CRANES; DRAGLINE, SLACKLINE HOISTS; ELECTRIC CAR-PULLERS; CRAWLER TRACTORS; GRAB BUCKETS; GASOLINE, ELECTRIC, STEAM HOISTS; MOTOR TRUCK WINCH EQUIPMENT.

Write for Bulletins and Catalogs covering any of the above products in which you are interested.



Specifications

Speeds: Hoisting—150 ft. per min. Swinging—5 revolutions per min. Travel—75 ft. per min.

Power Plant: Gasoline or Electric. Heavy duty, 4 cylinder, 47 H. P. Engine or 30 H. P. Electric Motor. Depth of Cut, 6 ft. 6 in. at 30 degree angle. Width of Cut 31½ in. Radius of Rear End, 8 ft. 1 in. Shipping Weight, 31,000 lbs.

Special Features

1. Full Half Yard Struck Measure.
2. Full Circle Swing.
3. Long Reach at Effective Height from 23 ft. 6 in. reach at 8 ft. 4 in. clear height to 17 ft. 9 in. reach at 17 ft. 3 in. clear height.
4. Three hand levers entirely control the digging operation.
5. Swinging in either direction accomplished by pressure on either of two pedals, allowing quick reversing without necessity of applying brake to limit rotation.
6. Live boom under constant control of operator through single lever, which actuates clutch or releases automatic service brake.
7. Full power of engine on crowd through cables, which allows shaking of dipper; also capable of jacking shovel out of deep mud.
8. Shovel can be moved or steered with cab in any position.
9. Steel Cab with ample windows, cut away on left side to give clear vision.
10. Standard machine arranged to be easily converted to ditcher or other attachment.

Attachments: Shovel, Ditcher, Skimmer, Clamshell, Dragline, 30 ft. or 35 ft. Crane Boom for Hook or lifting magnet.

ORTON CRANE & SHOVEL CO.

608 S. Dearborn St., Chicago

Manufacturers of Cranes, Shovels, Draglines, Ditchers, Skimmers and Buckets

Factory: Huntington, Ind.

Branch Offices

Cleveland—7629 Broadway
New York—72-74 Warren St.
Pittsburgh—House Bldg.
St. Louis—2339 Pine St.
Denver—Boston Bldg.

Portland, Ore.—Third and Hawthorne Sts.
San Francisco—19th and Indiana Sts.
Los Angeles—115 S. Los Angeles St.
Dallas—Commerce and Exposition Sts.
Milwaukee—1301 First National Bank Bldg.

Detroit—6464 Epworth Blvd.
Philadelphia—20 S. 15th St.
New Orleans—P. O. Box 682
Richmond, Va.—Electric Bldg.
Salt Lake City—320 S. Second St.

Products: Gasoline, Steam and Electric Locomotive Cranes; Gantry Cranes; Flexible Crawling Tread Cranes, Shovels, Draglines, Ditchers and Skimmers; Truck Cranes; Crane Trucks; Clamshell, Orange-Peel and Scraper Buckets.

The completeness of the line of ORTON excavating and material-handling equipment makes it possible for contractors, highway and street departments, etc., to select types and sizes to exactly meet their requirements and be the most profitable to operate.

Flexible (spring type) crawling tread cranes are made in a wide range of sizes, with lifting capacities from 1½ tons or a ½-yard bucket on a 30-foot boom to 5 tons or a 2-yard bucket on a 60-foot boom.

ORTON Flexible (Spring Type) Crawling Tread Crane with 40-Foot Boom and ¾-Yard Clamshell Bucket

Truck cranes made for mounting on the chassis of a 5 or 7½-ton truck have a lifting capacity of 5 tons at a 10-foot radius, and will handle a ½-yard bucket with a 20, 24 or 28-foot boom. Crane trucks are made with similar capacity.

Shovels, draglines, ditchers and skimmers are made with capacities of ½, ¾, 1 and 1¼ cubic yards, and with boom lengths to suit individual requirements.

All types and sizes have speedy full-revolving swinging, sizes ¾-yard and over being equipped with the famous ORTON "roller bearing" swing. Other standard equipment includes: Separate clutch shaft for traveling, steering, booming, hoisting, crowding or pulling; ORTON Power Applied Clutches; Alemite-Zerk lubrication; efficient gasoline engine or electric motor; roomy, all-steel cab with the operator's position well up in front to give a clear view of the work, and many other features that contribute to the successful operation of ORTON machines on road and street work in all sections of the country.

ORTON ½-Yard Gasoline Shovel with Flexible (Spring Type) Crawling Tread and Direct Gear-Driven Crowding Mechanism

Clamshell Buckets: The ORTON clamshell bucket has weight enough to bury itself in the material—spread enough to collect a full load every time—speed enough to insure at least three trips a minute. Closing action is powerful and fast, and smooth inside surfaces afford a lightning-quick discharge. ORTON improvements in design and construction make this bucket ideal for excavating and for handling all kinds of loose materials.

It has flat braced back arms, straight lead cable sheaves, bronze bushed interlocking hinges, Alemite-Zerk lubrication, and other advantages that make it the easiest operating and sturdiest bucket built.

Made in sizes from ½ to 5 cubic yards; can be fitted with removable teeth.

ORTON Dragline with 45-Foot Boom and 1-Yard Bucket

THE UNIVERSAL CRANE COMPANY

952 Swetland Bldg., Cleveland, Ohio

Manufacturers of Motor Truck and Crawler Cranes, Shovels and Draglines

BRANCH OFFICES

New York—30 Church St.
Atlanta—1207 4th National Bank Bldg.
Dayton—10 Lonsdale Ave., Oakwood
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Agents in all principal cities in the United States and abroad

Products: TRUCK CRANES, CRAWLER CRANES, TRENCH HOES, SKIMMER SCOOPS, SHOVELS, DRAGLINES.

The Truck Crane: The Universal Motor Truck Crane came into being 10 years ago, due to the increasing demand for mobility in construction equipment, especially for road building. Designed by men and built in shops devoted exclusively to truck cranes, Universal offers you the accumulated experience of over 10 years of truck crane experience. Its ready acceptance by road builders is proof of its economical application to such work.

Six ton Universal Crane, mounted on motor truck, equipped with Motor Truck Crawler. Crane equipped with combination 24 ft. crane boom and ½ yd. ditcher Shovel Attachment

General Specifications:

Motor—47 H. P. Waukesha, 4½x6¼ in. 1,000 R.P.M. Ricardo Head.

Swing Speed—6 R.P.M. Full circle.

Hoist Line Speed—150 F.P.M.

Outriggers—NONE, patented stabilizing jacks and stirrups permit traveling with load suspended.

Lubrication: Grease, Alemite pressure; oil feeders and wells.

Bushings: Bronze throughout.

Gears: High carbon, heat treated, cut teeth.

Total height of crane mounted on motor truck (approximately) 11 ft. 7 in.

Swing Clearance: 7 ft. 6 in.

Capacities	5 ton crane	6 ton crane	7½ ton crane
10 ft. radius	10,500 lbs.	12,000 lbs.	*15,000 lbs.
15 ft. radius	6,000 lbs.	7,000 lbs.	8,500 lbs.
20 ft. radius	4,300 lbs.	5,000 lbs.	6,000 lbs.
24 ft. radius	3,300 lbs.	4,100 lbs.	5,000 lbs.
28 ft. radius	2,700 lbs.	3,300 lbs.	4,200 lbs.
32 ft. radius	2,300 lbs.	2,900 lbs.	3,500 lbs.

*Can also be furnished as standard to lift 10 tons at 10 ft. radius.

Its Uses: Based on the work of hundreds of installations, the following are some of Universal's jobs in building and maintaining roads. Many contractors are using one Universal to handle all of these jobs on a single contract.

- Unloading cars
- Building stockpiles
- Loading trucks
- Charging bins
- Grading streets
- Widening streets
- Driving piles
- Removing road slides and slips
- Handling batch boxes
- Stripping gravel
- Loading machinery
- Building ditches
- Building berms
- Digging for bridge abutments
- Building culverts
- Snow removal
- Unloading and erecting bridge timber and steel

A Few of the Many Users: The quality of Universal owners is proof of their success on Road Building. Here are a few of the highway departments using Universals:

Ohio State—11	Alabama—2
New York State—5	West Virginia—2
Illinois—2	
Georgia—2	Tennessee—2
South Carolina	New Mexico
North Carolina	Missouri

Also hundreds of Highway and General Contractors, Cities and Counties.

Booms:
Bucket work, 16 to 36 ft.
Hook block work, 16 to 56 ft.

Bucket Capacities: ½ to ¾ yd.

Boom Hoist: Planetary gear type with automatic positive locking device against dropping.

Winches: Optional: 12,000 lbs. single line pull, line speed 30 F.P.M.

Operation:
1 Man
3 Hand Levers
1 Foot Pedal

Weight of Crane: Ready for mounting, approx. 12,000 lbs.

Attachments (all interchangeable):

Clamshell	Hook Block
Dragline	Magnet
Trench Hoe	Post Hole Drill
Skimmer Scoop	Pile Driver
Shovel	Backfiller

Mountings (all transferable):

Motor Truck	Industrial Truck
Motor Truck Crawler†	Railroad Flat Car
Center Drive Crawler	Portal Pier
Heavy Duty Trailer	Barge

†Motor Truck Crawler: An attachment readily fitted to a standard 4 wheel truck mounting giving 8 rubber tired wheels for road travel, convertible in 15 minutes to a high speed crawler rear end, travelling at truck speeds.

12 to 14 cars unloaded in 10 hours

TOP
½ yd. bucket and 36 ft. boom keeping inundation bin charged to capacity

CENTER
Shovel Attachment removing slides, Monongalia County, W. Va.

Road ditching and building berms

G. H. WILLIAMS COMPANY

Erie, Pa., U. S. A.

Manufacturers of Clamshell and Dragline Buckets

Branch Offices: New York Pittsburgh Cleveland Chicago

Products: CLAMSHELL AND DRAGLINE BUCKETS FOR EVERY CLASS OF DIGGING AND REHANDLING.

WILLIAMS
FAST-DIGGING BUCKETS

You are always sure of results when you buy a Williams—

As specialization in bucket building for more than a quarter century enables us to definitely guarantee the **Digging Ability** and **Capacity** of every Williams Bucket, so long as it is used on the work for which it is recommended.

"Double-Arch" Dragline Bucket: Even after years of hardest service, you will NOT see this bucket drawing in at the sides.

Correct weight distribution—the Williams "Double-Arch" Dragline digs right in, the instant the dragline is taut. No "skidding" over the top

The heavy digging lip of special cast alloy steel is reinforced by a heavy cast steel bridge. An arch above, and one below, gives **double rigidity.**

Perfect Control for Accurate Work: Watch the operator hoist the Williams "Double-Arch" Dragline Bucket without any spilling—and dump it fast and clean into a wagon or truck.

Williams "Single Line" gives good output with any hoist or derrick having only one drum for bucket operation. It is completely controlled by the hoist line and trip-rope.

Covers the same range of work as the 2-line Williams "Favorite"—material handling and light excavating.

Very fast digging and dumping action for a bucket of this type. With a hoist having one drum for the bucket, the Williams "Single Line" Bucket requires ¼ to ⅓ less time than the ordinary bucket of this type on digging or rehandling work

Williams "Favorite," a highly successful bucket for general service. Gives large output handling gravel, sand, coal and other bulk materials —on which work it can be reeved with only 3 parts of closing line, for extra speed. Its shorter cable overhaul means a big output.

And when reeved with 4-part closing line, has plenty of digging power for light excavation. Digging teeth can be easily bolted on.

The Williams "Favorite" for efficient all-around service in rehandling and light excavation

Williams "Universal Bucket" —A half-yard bucket built especially for faster operation of the light portable cranes that can handle 2 to 2¼ tons.

Guaranteed to out-dig and out-last any other half-yard bucket. It has the same substantial construction as the larger Williams Buckets. The lower operating headroom needed with the Williams "Universal Bucket" is another big advantage.

Williams "Universal Bucket"

Williams "Hercules," the **bucket that** *"makes hard digging easy."*

The four-part closing line pull is multiplied by the Power Arm leverage, giving unequaled digging power. The "Hercules" digs into hard materials such as hardpan, compacted gravel, etc., and **stands up to such work.**

For extra speed in handling heavy abrasive materials, the "Hercules" can be reeved with 3-part closing line.

Write for our new Bucket Book, showing many action photos of Williams Buckets.

In numerous cases the Williams "Hercules" has made good on extremely difficult digging that had previously been rated "too hard for any bucket to dig"

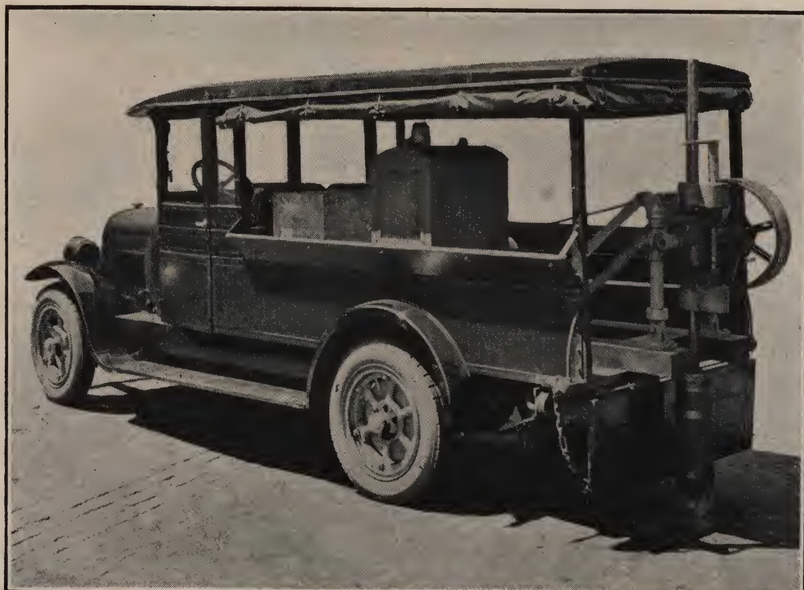
ACKER DRILLING CO.

Scranton, Pa.

Core Drills for Highway and Street Testing

Products: Core Drills, Highway Testing Drills, Street Testing Drills.

The Acker core drill, originally developed to withstand the hard service required of a prospecting drill above and below ground in the anthracite coal fields, is mounted on the rear of a one-ton truck for recovering test cores from highways and city pavements.



The cutting medium is chilled steel shot, which being fed into the top of a rotating core bit, gathers under the lower edge, and cuts out a core. One handful of shot is sufficient for cutting a five or six-inch diameter core from concrete eight inches thick.

Downward feed and travel are automatic, and may be regulated to core most efficiently the material being drilled. There are no counterweights, levers or regulating pulleys requiring constant attention of operator. While the machine is drilling he is free to mix concrete for plugging hole, label cores, record notes, etc. One man can run both truck and drill. No special skill is required.

Gears are either heat treated steel or high tensile manganese bronze. All parts are guaranteed for one year against failure from any cause.

Powered by LeRoi 6 H. P., 2 cylinder, radiator cooled, gasoline engine with clutch.

Net weight of drill, engine, tank with 50 gallons of water, tools, etc., 1,500 pounds.

It is possible to drill 10 to 20 cores per day, depending on thickness of concrete, distance between holes and amount of reinforcement.

Shipment from stock.

CURTIS PNEUMATIC MACHINERY CO.

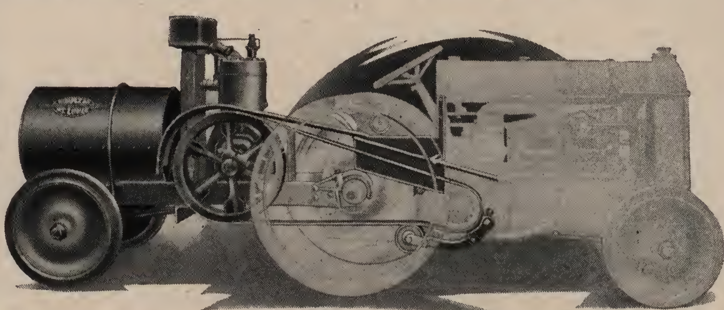
1918 Kienlen Ave., St. Louis, Mo.

Curtis Portable Compressor for Fordson

BRANCH OFFICE
5518-B Hudson Terminal, New York

Products: AIR COMPRESSOR, CURTIS PORTABLE COMPRESSOR FOR FORDSON.

Economy of this Portable Compressor results from the same moderate speed design, and simple rugged construction which makes Curtis Compressors standard for industrial service.



Mounting is an all-steel riveted frame on two wheels, coupling by six bolts to rear axle and steering gear of any standard Fordson tractor. Power is transmitted by self adjusting endless belt with tightening idler from regular size take-off pulley back to compressor fly wheel. Motive power always available from same Fordson engine through regular tractor transmission. Compressed air is cheaply and quickly provided by this Curtis Fordson Combined Unit wherever a Fordson can go. Movable under one man control.

Using low priced kerosene for fuel, the Fordson engine is at its best and drives the Curtis Portable at a considerably lower cost than gasoline driven compressor outfits.

Most Economical Purchase for Supplying One, Two or Three Rock Drills for Depths to Twelve Feet—Two Curtis units—each with a tractor—generally cost no more than a single unit compressor outfit of other types of two drill capacity, yet two Curtis outfits operating together will supply three drills. Two 120 cu. ft. Curtis units complete operating at distant points are no more expensive to purchase and operate than one 160 cu. ft. unit, which is subject to expensive pipe line losses.

One Curtis unit complete with Fordson ties up much less money than the ordinary engine driven portable of equal capacity which has no motive power.

On progressive work the Curtis unit shows big savings since progress is not interrupted by drafting men from other jobs to move compressor.

Long Life—Moderate speed Curtis design is built to outlast compressors direct connected to high speed engines and to provide an outfit of extra life at nominal cost.

Fully enclosed crank case protects working parts from dust and grit, decreasing wear and lengthening life.

EXCLUSIVE FEATURES

1. Independent Radiator and Fan Fly Wheel.
2. Built-in Jack Leg Platform supports.
3. Spring Tension Belt Tightener Pulley.
4. Controlled Sight Feed Lubrication.

Built-in Platform Supports—Jack legs enable one man to easily couple compressor to Fordson tractor—Provide steady support against vibration or rocking during compressor operation.

Water Cooling System—Equipped with own natural thermosyphon circulating system without pump or valves — Minimum over heating and vaporizing of lubricating oil or baking and gumming valves in tools, etc.

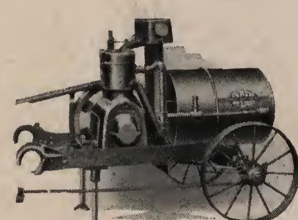
Automatic Lubrication—Curtis has the only lubricating system with controlled splash and with regulatable sight feed to cylinders—Assures sufficient lubrication with least oil, attention or trouble.

Self Adjusting Belt—Flywheel always aligned with Fordson pulley—Tightener idler and spring fits on standard take off flange—Maintains proper tension and avoids slipping and wearing belt—Endless belt provided with guard and horizontal adjustments for variation in length.

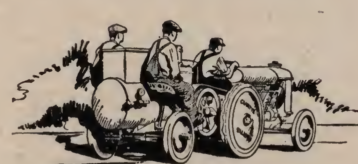
Tools Operated:

1 Rock Drill—12 ft. or	3 Riveting Hammers—or
2 Paving Breakers—or	3 Trench Spades—or
2 Rock Drills—6 ft. or	4 Caulkers or Reamers—or
3 Backfill Tampers—or	5 Light Riveters, etc.

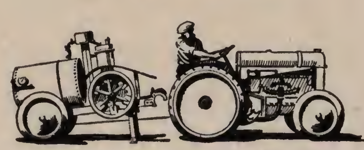
Compressor and Fordson Easily Coupled Together — Connection is made by screwing down jack legs thus raising front end of portable compressor so that couplings are above level of the tractor rear axle. Tractor is then backed in position, outfit lowered on jack legs, lug bolts slipped through couplings and nuts (2) tightened. Tractor front wheels and wheels of compressor outfit lined up by eye straight ahead clamp attached to steering arm (4 nuts) wheel rolled over belt, and belt slipped in place. This completes connection (10 minutes). When belt guard tightener and clutch holddown clips are bolted on, these need no further attention. Fordson must have speed governor (1200 RPM) and power take off pulley. Any Ford dealer can provide and attach these standard accessories.



View showing radiator and thermosyphon cooling system



Arranged at slight extra cost to carry tools and operators



INDEPENDENT PNEUMATIC TOOL COMPANY

600 West Jackson Blvd., Chicago, Ill. Factory at Aurora, Ill.

Manufacturers of Air Compressors and Pneumatic Contractors' Tools

SALES AND SERVICE BRANCHES

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Products: AIR COMPRESSORS, PAVING BREAKERS, CLAY DIGGERS, TRENCH DIGGERS, BACKFILL TAMPERS, CALKING HAMMERS, SHEETING DRIVERS, PNEUMATIC WRENCHES, RIVETING HAMMERS, AIR HOISTS, AIR DRILLS, GRINDERS, AIR HOSE, COUPLINGS AND ACCESSORIES.

Thor

Thor Air Compressor Mounted on Steel Wheels

The lighest, most compact and most powerful compressor of its size on the market. The only compressor with a super-charger, which enables it to deliver 26% more air than any other compressor of the same rating or capacity.

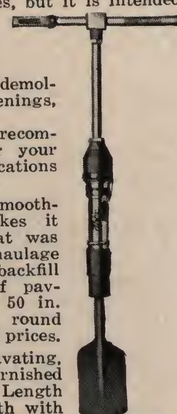
The Rix Super-Charger is an exclusive, patented feature of the Thor. It is not a complicated piece of mechanism but a simple and fool-proof arrangement that enables the piston on its idle or downward stroke to compress the additional air the Thor delivers.
The unit-type construction of the Thor is an advanced and improved feature of design. Both engine and compressor are mounted on a common crank case, eliminating gears, clutches and couplings. A one piece steel frame gives the Thor unit greater rigidity and helps to eliminate vibration.
The Thor Six Compressor can be had in a variety of mountings to suit individual requirements. Write for complete specifications and prices.

SPECIFICATIONS

Size of engine (4 cylinder, 4 cycle, valve-in-head type)	4¾" bore by 6" stroke
Horsepower rating of engine	32 at 800 R. P. M.
Speed of engine (maximum) R. P. M.	800
Size of compressor cylinders (2)	5¼" bore by 6" stroke
Displacement of compressor, per minute	116 cu. ft.
Amount of free air per minute actually delivered by compressor (corrected for temperature)	96 cu. ft.
Size of air receiver	20"x42"
Weight of outfit—skid mounted	2,500 lbs.
Weight of outfit mounted on steel wheel trailer	2,700 lbs.
Dimensions of outfit skid mounted	Length 7'6", width 2'4", height 4'6"
Dimensions of outfit mounted on steel wheel trailer	Length 7'6", width 5'0", height 5'6"

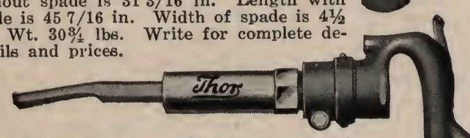
Thor 71R Pneumatic Wrench: This tool will pay for itself in a short time in putting on and removing a wide range of nuts from ½ in. to 1 in. It reduces the time from 100 to 300 per cent over the old hand method of doing this work. It can be used in close quarters quickly and conveniently. Maximum torque of machine at spindle is 756 in. lbs. Wt. 25 lbs. Write for complete specifications and prices.

Thor Paving Breaker: The recoil or "kick-back" has been eliminated in the Thor and the full effect of the blow is directed downward on the work. This is accomplished by the type of valve used and the relative position of the air ports. The operator is relieved from the fatiguing vibration usually experienced in tools of this type.
The Thor Breaker develops a powerful, hard-hitting blow and accomplishes a great deal of work. Freezing in severe weather has been eliminated to the minimum by the addition of a lower exhaust air port.
The steel retainer, as shown in the cut, is a new and patented feature, and prevents the steel from dropping out of the nozzle. The retainer, being a flexible chain, will not break or loosen if it were to strike the concrete when the steel goes to its full depth.
Thor Paving Breakers are rugged and well constructed. They are the product of an engineering staff that are specialists in air tool design and construction.
There are three sizes of Thor Paving Breakers.
The No. 240 is exceptionally speedy and is particularly adapted for breaking street concrete pavements, demolishing concrete structures, breaking rock in trenches, etc.
The No. 230 can also be used for these purposes, but it is intended for heavier work where an extremely hard blow is required and speed is not so essential.
The No. 241 is lighter in weight than the No. 230 or No. 240 and has proven very popular on side work, for making wall openings, demolishing foundations, for cutting small street openings, etc.
Tell us your requirements so that we can recommend the Breaker best suited for your work. Write for complete specifications and prices.

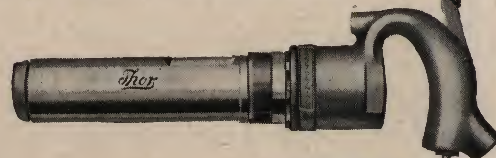


Thor Backfill Tamper: Speedy and smooth-running. A backfill tamper makes it possible to use all of the dirt that was excavated and eliminates the haulage of surplus earth. Rams the backfill harder and prevents settlement of paving later on. Length over all is 50 in. Wt. 22 lbs. Supplied with 5 in. round butt. Write for complete details and prices.

Thor Trench Digger: Used for excavating, tunnel and trench work. Can be furnished with grip handle for tunnel work. Length without spade is 31 3/16 in. Length with spade is 45 7/16 in. Width of spade is 4½ in. Wt. 30¾ lbs. Write for complete details and prices.



Thor Calking Hammer. Fast, powerful and efficient. Will calk a joint twice as fast as by hand. Length, without calking tool, is 13 in. Length, including calking tool, is 19 in. Wt. 13 lbs. Write for complete details and prices.



Thor Riveting Hammer. The fastest hammer on the market. Your men will like the feel of the handle—its perfect balance—its correct shape. Develops a powerful, hard-hitting blow. Because of its construction the air consumption is very low and it develops no back kick. A size for every need. Write for complete details and prices.

INGERSOLL-RAND COMPANY

11 Broadway, New York

Portable Compressors, Drilling Equipment, Pneumatic Tools

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OFFICES IN ALL PRINCIPAL FOREIGN CITIES

To insure correspondence against avoidable delay, all communications should be addressed to the place nearest the writer.

Products: Air Compressors, Oil and Gas Engines, Condensers, Rock Drills, Rock Drill Mountings and Accessories, Drill Steel, Drill Steel Sharpeners, Portable Hoists, Cameron Pumps, Air-Lift Pumping Systems, Pneumatic Tools.

Portable Air Compressors: Ingersoll-Rand Portable Air Compressors are driven by a four-cylinder, four-cycle tractor type gasoline engine, or either direct or alternating current electric motor of standard design. These compressors are furnished on the following standard style mountings: Steel wheels and axles; steel wheels with rubber tires; spring mounting having wooden wheels and rubber tires; or furnished without running gear for mounting on a motor truck or on skids. The smaller sizes can also be furnished as a Ford truck or Chevrolet truck outfit. The trucks can be purchased locally and the compressor furnished ready for mounting, as it simply bolts to the chassis; or, we will furnish complete outfits when desired.

Ingersoll-Rand Portable Compressor on Steel Wheels and Axles.

"Leyner" Drill Steel Sharpeners: "Leyner"-made bits are correctly formed, cutting edges are sharp and all are exact duplicates. Accurate gauging permits 1/16 in. variation in gauge of successive steels so that smaller diameter starter bits can be used to bottom a desired size hole.

"Leyner" No. 34 Sharpener, for bits up to 2½ in. diameter.
"Leyner" No. 50 Sharpener for bits up to 3⅝ in. diameter.


No. 34 "Leyner" Sharpener.


CC-35 Pile Driver for Sheet Piling

Pile Driver: For driving wooden sheet piling in any ground that piling will penetrate without breaking. Timber planking is recommended in sizes 2 in. x 8 in., 2 in. x 10 in. and 2 in. x 12 in. in lengths to 20 ft. Sheet piling of greater thickness than 2 in., also round piling of small diameter can be used by shaping pile ends to fit driving head of machine.

Paving Breakers: Tools for tearing up pavement and hard surfaces such as concrete, asphalt, wooden block, asphalt block, bitulithic or other road surface materials. Paving breakers are also used with equal success for resurfacing, cutting trenches, enlarging man-holes, tearing out old foundations, retaining wall, floors or for other forms of demolition.


Paving Breaker.

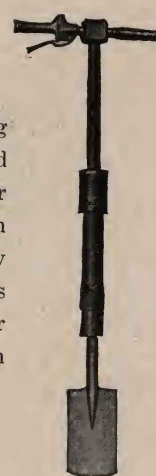
"Jackhamers": One of these one-man, lightweight self-rotating hand hammer drills will put down holes as deep as 25 feet, averaging from 100 to 150 feet per day in hard rock. There are six different sizes of "Jackhamer" Drills and each size has its particular uses.


DCR-23 "Jackhamer."

Trench and Clay Diggers: These pneumatic tools will do the work of five men using ordinary hand picks. In fact, one man with a trench or clay digger can pick loose enough stiff clay, shale or hard ground to keep five shovelers busy.


Backfill Tamper

Backfill Tampers: For tamping backfill in trenches or on road surfacing the pneumatic tamper enables a workman to do ten times the work he can do by hand. An air tamper strikes 600 hard, snappy blows per minute, ramming the fill down hard.


I-R Trench Digger.

O. K. CLUTCH AND MACHINERY COMPANY

Columbia, Pa.

Manufacturing of Hoisting Machinery and Portable Air Compressors

Distributors in Principal Cities

Established 1904

O. K.

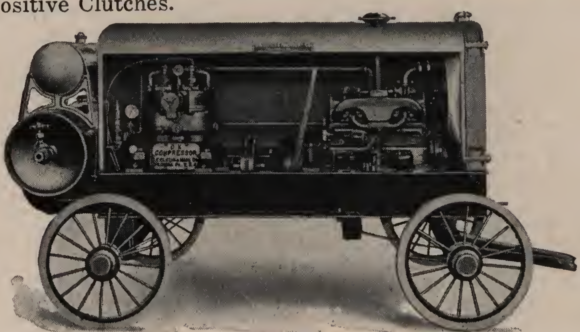
TRADE MARK REGISTERED

Products: O.K. Portable Gasoline and Electric Air Compressors, O.K. Gasoline and Electric Hoists.

O. K. Gasoline and Electric Hoists in single, double and three-drum types, reversible and non-reversible; with or without boom swinger. From 8 H. P. to 130 H. P., with two and four cylinder gasoline engines; from 5 H. P. to 125 H. P. with electric power.

O. K. Portable Air Compressors in three sizes: 120 ft., 160 ft. and 265 ft. of free air piston displacement. Mounted on steel truck with steel wheels or rubber tired wheels, also spring truck or auto truck mounting. Gasoline or electric power.

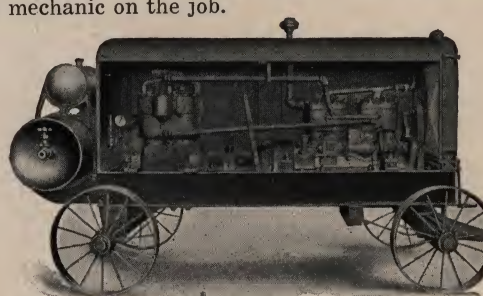
O. K. Friction Clutches and Combined Friction and Positive Clutches.



120 Ft. Compressor on Rubber Wheels

O. K. Portable Air Compressors: Produced to meet the demand for a reasonably priced, high capacity compressor. Made in three sizes with capacity ratings of 120, 160 and 265 cu. ft. of free air per minute.

The Compressor unit is readily accessible, with unusually large water passages for complete cooling under all conditions. Valves are of the Duo Plate type of special hardened steel with a separate plate over each port. Valves are removed by lifting bolted caps, without taking off the head, a feature much appreciated by the mechanic on the job.



120 Ft. Compressor on Steel Wheels

Radiators on the O. K. Compressors are of our own special design, with cast iron head, tank and side members and a high efficiency core that can not be broken by freezing.

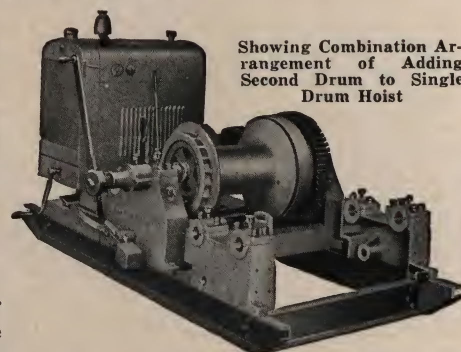
Engines are the standard heavy duty industrial type, with reserve capacity for operation under any condition.

Our special carburetor control saves gas by idling the engine when not supplying air.

Each O. K. Compressor is complete with engine, compressor unit cooling system, fuel tank and extra large riveted air tank mounted on a one piece welded steel frame. Equipped with safety valve, suction unloader and necessary tools.

Ask for Catalog No. 28-B on O. K. Air Compressors and Catalog No. 28-A on O. K. Hoists.

O. K. Hoists: Side stands and cross connecting sections are of extra heavy box type construction. All gears have generated cut teeth and are hobbed from solid blanks. All pinions are of machined steel, insuring strength and reliable service.

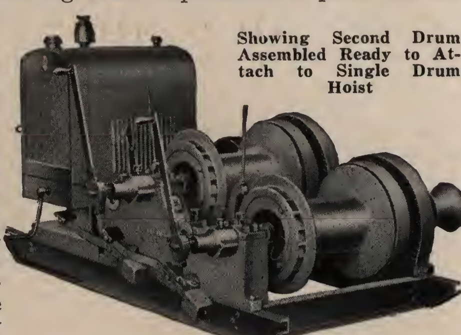


Showing Combination Arrangement of Adding Second Drum to Single Drum Hoist

Shafting in O. K. Hoists is extra large size, turned and ground, with large bearing areas. Smooth running is assured at all speeds.

O. K. Frictions are of the double cone type and are lined with asbestos. Not affected by moisture, heat or cold. This type friction will outwear several sets of wood friction. To operate these frictions, an easy end thrust ball bearing operating device is used. The end thrust bearings make O. K. Hoists easy to operate and reduce power for hoisting to a minimum.

All parts are machined and drilled in jigs and fixtures, thus insuring exact duplication of parts for replacements if required.



Showing Second Drum Assembled Ready to Attach to Single Drum Hoist

O. K. Hoists can be supplied with gasoline, electric or belt drive in any required type; reversible or non-reversible; single, double, or triple drums. By our interchangeable system, a single drum hoist can be converted to a double drum hoist by simply bolting the second drum, complete with side stands, etc., to the single drum machine. No machine work is necessary. The third drum can be added in the same manner. The O. K. is the only hoist having this feature.

Our complete Hoist Catalog No. 28-A sent on request.

Some open territory is available for distributors.

SCHRAMM, INC.

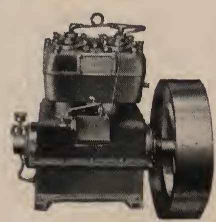
West Chester, Pa.

Manufacturers of Air Compressors

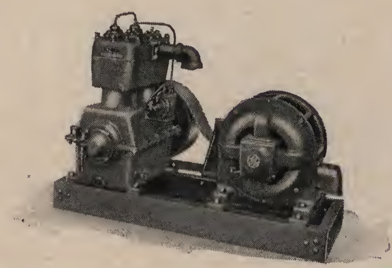
New York   Chicago   Pittsburgh   Philadelphia   Tulsa   Boston   San Francisco

Representatives in All Principal Cities

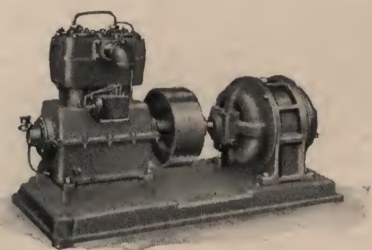
Products: Air Compressors.



"Schramm" Vertical Belt Driven Compressor

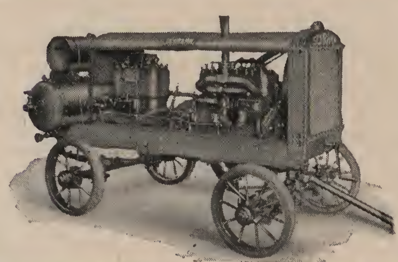


"Schramm" Motor Driven Compressor for Short Belt Drive



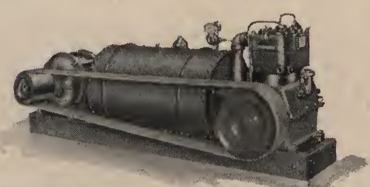
"Schramm" Direct-Connected Motor Driven Stationary Compressor

"Schramm" Direct-Connected Motor Driven Portable Compressor

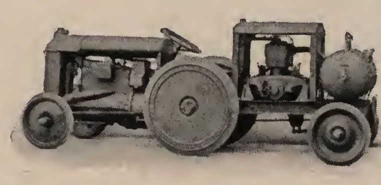


"Schramm" Multi-Cylinder Air Compressor on Spring Mounted Trailer

"Schramm" Engine Driven Compressor for Mounting on Various Type Motor Trucks



"Schramm" Belt Driven Compressor Complete with Tank



"Schramm" Compressor Tractor Combination

The illustrations above represent various types of "SCHRAMM" Air Compressors, including the Multi-Cylinder Engine Driven outfits that can be furnished in different mountings, Portable Motor Driven, Stationary outfits for Motor or belt drive, built in a variety of sizes.

The Multi-Cylinder Engine driven outfits are completely housed with removable steel sides and equipped with extra heavy riveted air tanks. Operated by the heavy duty type Buda engine, which is connected to the compressor by means of a heavy type flexible clutch that permits the starting of engine separately from the compressor, a distinctive "SCHRAMM" feature. These outfits are built in sizes with displacements of 60, 120, 180 and 240 cu. ft., so that we offer greater capacities without any increase in price.

Write for the "SCHRAMM" Catalog illustrating our complete line of Air Compressors.

SULLIVAN MACHINERY COMPANY

158 South Michigan Ave., Chicago, Illinois, U. S. A.

Air Compressors and Drilling Machinery

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†Factory

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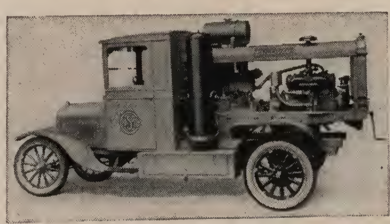
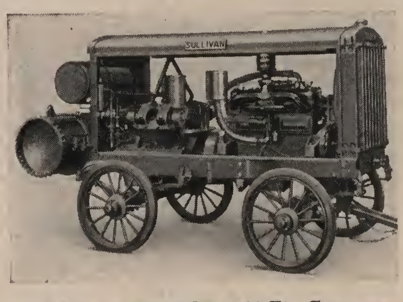
Algiers, Brussels, Calcutta, Durban, Johannesburg, Lima, London, Madrid, Toronto, Mexico City, Oslo, Turin, Paris, San Juan, Vancouver, Santiago, Shanghai, Sydney, N. S. W., Tokyo

Local distributors in all principal cities. Consult your phone book or city directory under "Sullivan Machinery Co."

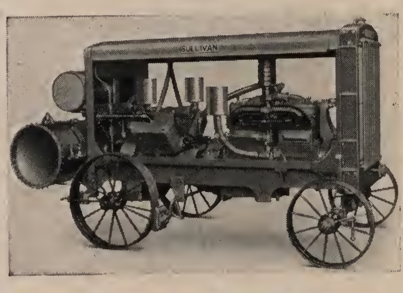
Sullivan Vibrationless Portable Compressors: Sullivan Vibrationless Compressors are available in six models; "WK-312," 110 and 160 ft.; "WK-314," 220 and 310 ft.; all Buda Engine-powered; or in "WK-322," 103 ft.; and "WK-324," 206 ft. compressors with electric motor drive. All are good for 100 lbs. pressure. They can be had on steel wheels, rubber tired trailer trucks, skids, or ready for mounting on your own truck. The unusual freedom from vibration of Sullivan Compressors makes them especially trouble-free, and long lived. It is due to perfect static and dynamic balance, to harmony of power impulses with load demands, to positive interlocking gears, and one-piece electric steel underframe. "Wafer" valves, sweep control unloading, Protectomotor air filters, and positive, automatic lubrication are other features. *Send for Complete Catalog 4583-F.*



"WK-312" Vibrationless 110-Ft. Compressor on Ford Truck



"WK-314" Vibrationless 220-Ft. Compressor on Trailer Truck



"WK-314" Vibrationless 310-Ft. Compressor on Steel Wheels

"L-7" Rotator

Sullivan Rotator Rock Drills: Sullivan Rotators are 45-lb., one-man, self-rotating hammer drills equipped with steel retainer and automatic lubrication, and requiring ⅞-in. solid or hollow drill steel. They are all-around rock drills, used for block-holing, shallow drilling on ledge or in trenches, deep drilling in quarries or horizontal toe-hole work on high benches. Numerous models are available, including medium weight and heavy sinkers, augers and one steam drill. Rotators may be mounted on columns or tripods for down hole or drifting work. *Complete Catalogs 4581-O, 4581-Q, 4581-S.*

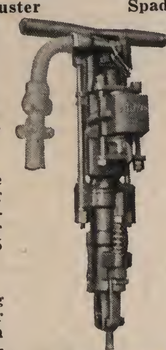
Sullivan "T-3" Water Drifter: A 156-lb. high power water jet drifting drill, using 1¼-in. steel; and equipped with automatic rotation, 24, 30, 36-in. feed, and separate air and water throttles; may be fitted with long shell for down hole drilling from a tripod or quarry bar. *Catalog 4581-M.*

"DW-221" Buster

"DH-361" Spader

Sullivan Concrete Breakers: Sullivan Busters are available in "DW-221" 75-lb. models that will smash the hardest reinforced concrete, or "DP-221" 48-lb. tools for cutting light concrete and asphalt and for demolishing building walls. "DW-221" uses 1⅛-in. steel; "DP-221" 1-in. Tampers, asphalt cutters, chisels, pick point moils, and pile hammer tools are available for the Busters. *Catalog 4581-I.*

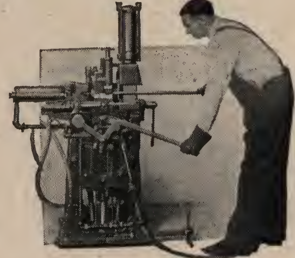
Sullivan Clay Spaders: Sullivan Spaders are 22¾-lb. compressed air tools for excavating hard clay. Short-shanked spades for tunneling, or long-shanked T-handle spades for open trench work, are available with 4, 5 and 6-in. blades. *Catalog 4581-N.*



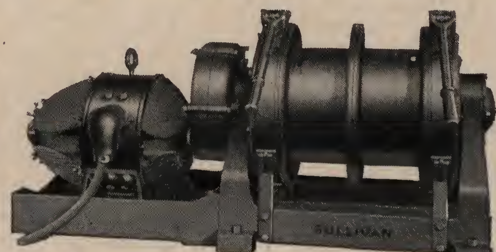
"L-5" Rotator

Sullivan Portable Hoists: For handling drag scrapers in gravel pits, Sullivan Turbinair and Electric Scraper Hoists are available in 6½, 7½, 10, 15 and 25 H. P. models. Machines are compact and light, easily moved from job to job, require little attention and have all parts completely enclosed to keep out the dust and rain of the open pit. Single drum hoists are also available. *Catalogs 4576-F, 4576-G and 4576-H.*

Sullivan Portable Drill Sharpener and Sullivan Portable Furnace: A Sullivan Portable Sharpener and "GF-2" Furnace will make or re-sharpen ⅞ to 1⅛-in. steel up to 2½-in. gauge, or forge collar shanks, eight times faster than hand labor. The Sharpener weighs only 1,100 lbs., is low priced and will run from your portable compressor without affecting the efficiency of your other air tools. *Complete Catalogs 4572-I, 4574-C.*



Portable Drill Sharpener



"HDE-2" 15 or 25 H. P. Scraper Hoist

Handling Crushed Stone

Cost of Handling Crushed Stone.—In handling stone after it has been crushed to 2½-in. size, or smaller, a shovel is used, and the output of a man depends very largely upon whether he is shoveling stone that lies smooth upon boards or upon the ground. I have often had 6 good shovelers unload a canal boat holding 120 cu. yds. loose measure of crushed trap rock (2-in. size) in 9 hrs., but after breaking through to the floor the shoveling was comparatively easy; this is 20 cu. yds. loose per man per day shoveled into skips. In shoveling from flat cars into wagons the same rate can be attained, but in shoveling from a hopper-bottom car, where there is at no time a smooth floor along which to force the shovel, an output of 14 cu. yds. loose measure is a fair 10-hr. day's work. In shoveling broken stone off the ground into wagons it is not safe to count upon much more than 12 cu. yds. loose measure per man per 10 hrs. A careful manager will, if possible, provide a smooth platform, preferably faced with sheet iron, upon which to dump any stone that is to be re-handled by shovelers. Small stone, ¾ in. or less in diameter, is easily penetrated by a shovel and need not be dumped upon a platform. A clamshell bucket operated by a locomotive crane, or derrick, is doubtless the most economic method of loading broken stone from cars or stock piles, where the quantity to be handled warrants the installation.

Unloading Cars with a Clamshell Bucket.—Using a gasoline crane with a 35-ft. boom and a clamshell bucket of ¾ cu. yd. capacity, an operator, and two men in the freight car cleaning up, unloaded 200 yds. of crushed stone into stock piles per 10-hr. day. The same outfit unloaded 300 cu. yds. of sand per day. The freight cars held 33 cu. yds. In estimating the cost of handling concrete road aggregates with a clamshell it should be remembered that there will usually be delays both in the delivery of materials by the railway and in taking the materials away to the road. Hence it is usually necessary to estimate the cost of handling aggregates on the basis of the average output of the concrete mixer after allowing for all delays.

If a 21-cu. ft. mixer averages 75 days worked during a season and puts out 200 cu. yds. of concrete per 10-hr. day, the total output for the season is 15,000 cu. yds. of concrete, which will involve the handling of about 1.4 cu. yd. of stone and sand per cubic yard of concrete, or 21,000 cu. yds. of loose materials per season.

In estimating the output of a clamshell bucket, it should be remembered that in handling broken stone it will usually average only about 60 per cent of its rated capacity per scoop. If its rated capacity is 0.75 cu. yds. its actual average will usually be about 0.45 cu. yds.

A locomotive crane may be mounted on wheels to which flanges can be bolted if the crane is to run on a railway track. Freight cars may be "spotted" by a cable attached to the locomotive crane.

It is a common practice to unload freight cars into bins that are built in sections bolted together, so that they may be quickly taken down and moved. Motor trucks may drive under the bins and be quickly loaded. A series of bins having a total capacity of 150 cu. yds. of stone and 100 cu. yds. of sand will hold nearly one day's supply for a 21E mixer. Stock piles should be made near the bins.

Unloading Scows with a Clamshell.—Mr. Gustav Kaufman used a 1⅝ cu. yd. clamshell bucket operated by a 50-hp. electric motor, and unloaded 600 cu. yds. of broken stone per day from scows. In addition to the operator of the clamshell bucket, about 8 men were kept busy trimming up the stone in the scow not handled by the bucket. The clamshell bucket dumped into a 10 cu. yd. hopper provided with a shaking chute which fed the stone onto a belt conveyor. Careful timing showed that the bucket made 1 1/9 scoops per minute, averaging 0.9 cu. yd. per scoop, or about 56 per cent of the rated capacity of the clamshell. Tests showed that it required 20 hp. while loading, 42 hp. while lifting, 42 hp. while swinging loaded, and 20 hp. while swinging back empty. But if we assume a constant average expenditure of 30 hp., we have about 24 kw., or 240 kw. hrs. per day. Based upon these data we would have the following approximate cost:

	Per day.
1 operator	$ 7.00
240 K. W. hrs. electricity at 4 cts.	10.00
8 laborers at $5.00	40.00
Total	$57.00

Another $3 per day would cover the plant interest and maintenance. At this rate the cost is 10 cts. per cu. yd.

Cost of Handling Broken Stone with Derrick. Where crushed stone must be handled with a derrick, as in unloading boats, I have found the following to be about the best that can be done per day:

	Per day
6 shovelers at $5.00	$30.00
1 hooker on	4.00
2 tagmen (swinging the boom)	8.00
1 dumpman	4.00
1 water boy	2.00
1 team on derrick	7.00
1 foreman	7.00
120 cu. yds. (loose) at 52 cts.=	$62.00

It commonly costs about 60 cts. per cu. yd. (loose measure) to unload a boat of broken stone using skips holding 18 cu. ft. each, and a team on the derrick for raising them.

The following shows the cost of unloading flat cars containing broken stone (2-in. size), using a derrick with a bull-wheel for "slewing" the boom:

5 shovelers at $5.00	$25.00
1 dumpman	4.00
1 engineman	7.00
½ ton coal at $8	4.00
100 cu. yds. (loose) at 40 cts.=	$40.00

In this case a stiff-leg derrick, 40-ft. boom, with a bull-wheel, operated by a double cylinder (7x10) engine, handled self-righting steel buckets holding 20 cu. ft. each. Water for the engine was delivered in a pipe. The engineman was the foreman.

In neither of the two cases just cited is the cost of installing the derrick included, nor is the interest and depreciation of plant included. It takes 6 men and a foreman one day to dismantle and move a stiff-leg derrick a short distance (100 or 200 ft.), and one more day to set it up again, or $75 for the two days' work. This includes moving the engine and the stones used to hold the stiff legs down; and it applies to a slow gang of workmen.

GRUENDLER PATENT CRUSHER & PULVERIZER CO.

St. Louis, Mo.

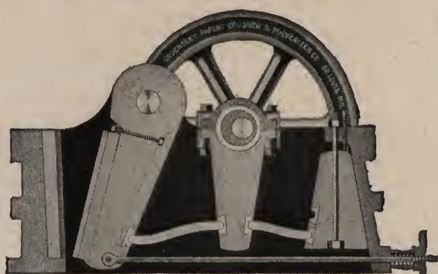
Crushing, Pulverizing, Screening and Conveying Machinery

DISTRICT OFFICES

Max Mosher, 1269 Broadway, New York City, N. Y.
F. W. Bauer, 129 15th St., New Cumberland, Pa.
Sherman J. Boss, 4906 Paddock Road, Cincinnati, Ohio
Port Huron Machinery Co., West Fifth and Market Sts., Des Moines, Iowa
W. L. Hutcheson, 201 E. California St., Oklahoma City, Okla.
Tri-State Machinery Co., 308 N. Washington Ave., Minneapolis, Minn.
R. J. Roath, W. 922 Riverside, Spokane, Wash.
Port Huron Machinery & Supply Co., 817 R St., Lincoln, Nebr.
Port Huron Machinery Co., 414 First Ave., N., Minneapolis, Minn.
Thaleg & Hock, Inc., 236 N. Clark St., Chicago, Ill.
John R. Gray, Inc., 717 Board of Trade Bldg., Portland, Ore.
John R. Gray, Inc., 487 Chamber of Commerce Bldg., Los Angeles, Calif.
Southern Construction & Mill Supply Co., Houston Merchants Exchange, Houston, Texas
H. C. Clapper, 703 N. Wabash, Marion, Ind.

Products: JAW CRUSHERS FOR GRAVEL AND TRAP ROCK, SWING HAMMER CRUSHERS FOR ALL MATERIALS INCLUDING CRUSHERS FOR MACADAM, ROCK ASPHALT AND CONCRETE STONE; ELEVATORS, REVOLVING AND SHAKER SCREENS, BUCKET AND BELT CONVEYORS. COMPLETE CRUSHING PLANTS DESIGNED AND EQUIPPED.

Gruendler Jaw Crushers: Gruendler all-steel Jaw Crushers, stationary or portable, in capacity from 5 yards to 75 yards per hour, handling over-size gravel stone for road work. Most durable and easiest type of crusher to handle.



Interior View of Jaw Crusher.

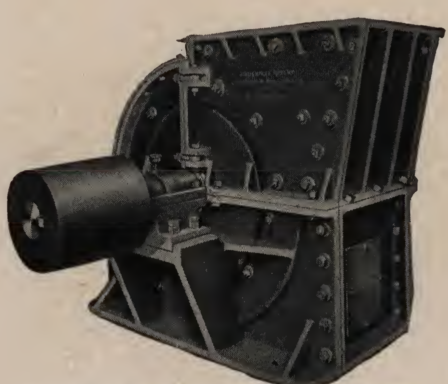
This illustration shows the Gruendler compound jaw crusher, which is widely used for many road jobs on account of its ease in adjusting from one fineness to another. It has a range depending upon the size from ½ in. up to 3 in., which adjustment can be made while the crusher is in operation. The crusher frame is made entirely of semi-steel, with manganese jaws and is adapted for handling the hardest of rock, nigger heads or gravel.

Hercules and Monster Type Hammer Crushers: For crushing from 10x36 in. down to 2½ in., 1½ in., ¾ in. and finer with one machine and in one operation. Provides large capacity and uniform product which can be easily adjusted as to size by changing grates. One Crusher does the work of a primary crusher and a secondary crusher, hence only small investment required. Operation cost and power is low because of swing hammer principle and fewer operations. Manufactured in various sizes and adapted to from small quarries to large producers. Also furnished mounted on truck with elevators.

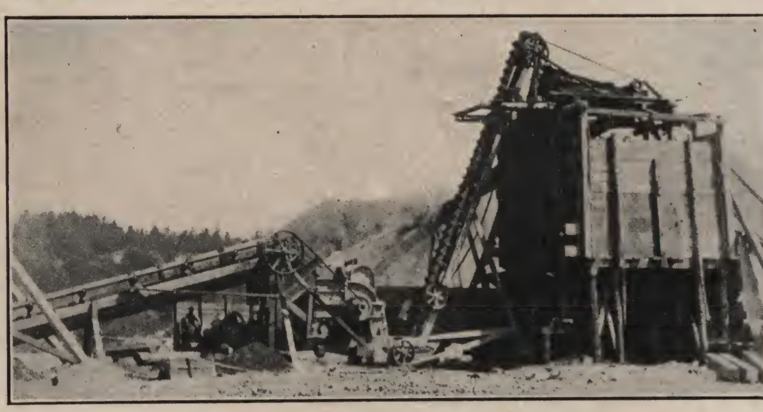
Portable Jaw Crusher With Elevator and Chute Screen: This machine is known as a *Road Maker* on account of its accessibility and ease in conveying from one job to another on account of its sturdy construction and dependable operation. Only the very best materials are used in *Gruendler* equipment.

Portable Jaw Crusher with Folding Elevator.

Complete Plants: We are in position to furnish equipment for complete crushing plants, including crushers, pulverizers, revolving and shaker screens, elevators, drags, bins, etc. Detailed information and price will be gladly furnished without obligation.



Gruendler Monster Type Hammer Crusher



A Gruendler Installation on the Pacific Coast

UNIVERSAL CRUSHER COMPANY

641 C Ave. W., Cedar Rapids, Iowa

Crushing, Pulverizing, Conveying and Screening Equipment

Products: Jaw Crushers, Hammer Pulverizers, Revolving Screens, Bucket and Belt Conveyors.

ALL STEEL

Large Opening General Crushers: Widely used and highly recommended for use in all stone quarries and in gravel deposits where round heads are over six inches in diameter. Furnished in portable style with or without elevators for contractors and road builders.

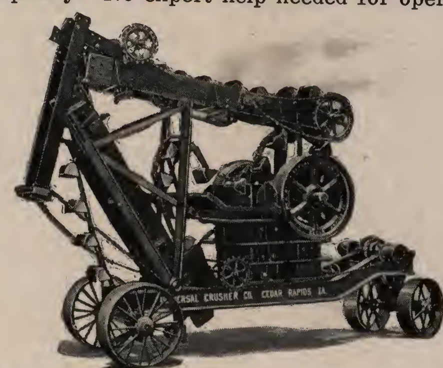
No.	Jaw Opening	Speed R.P.M.	Wt. on Skids	H.P.	Capacities in tons per 10 hrs. 2½ in.	1½ in.	¾ to 1 in.
1536	15x36	175-200	15850	40-50	300-450	200-275	150-200
1524	15x24	175-200	12960	30-35	225-300	175-200	125-150
1520	15x20	175-225	11900	25-35	150-200	100-150	75-100
1236	12x36	175-200	15875	40-50	250-350	175-225	125-175
1224	12x24	175-200	13000	30-35	175-225	150-175	80-120
1220	12x20	175-225	11950	25-35	150-200	100-150	75-100

Gravel and Rejection Crushers: Contractors and commercial stone producers will find these crushers to be the most satisfactory and economical machines manufactured. Wherever specifications call for fine uniformly crushed stone and gravel there you will find Universal Crushers. Will crush to pass a 1 in. ring. Very strong and rigid yet light enough for convenience in portable crushing and screening plants.

No.	Jaw Opening	Speed R.P.M.	Wt. on Skids	H.P.	Capacities in tons per 10 hrs. 2½ in.	1½ in.	¾ to 1 in.
836	8x36	175-225	10700	25-35	200-300	120-175	95-150
824	8x24	175-225	8290	20-25	150-225	80-120	65-100
818	8x18	225-275	6150	15-20	125-175	60-90	50-75
816	8x16	250-300	4175	12-15	80-100	50-60	40-50
812	8x12	275-325	2500	10-12	35-50	25-35	20-30
810	8x10	275-325	2360	6-10	25-40	20-30	15-20

Specialists: For more than twenty years we have been serving the stone crushing trade, always keeping pace with the demand for better materials for road building and concrete construction. We know the needs of these fields and are in a position to supply them.

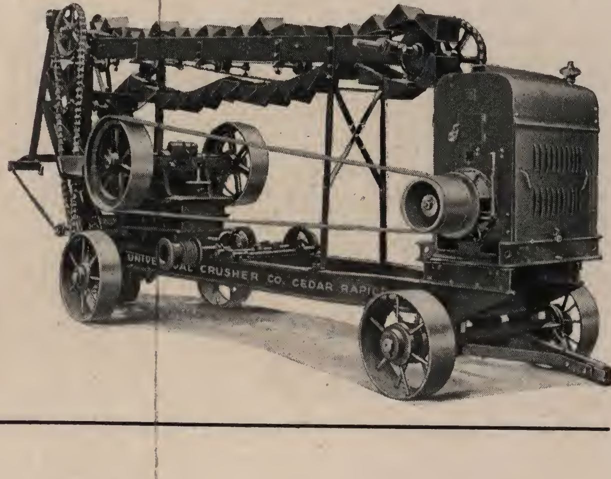
Crushers: We build more than twenty sizes with capacities up to 450 tons daily. Every machine has been designed for hard service. Standard equipment on all sizes includes reversible manganese steel jaws of highest quality, special high carbon alloy steel eccentric shafts, dust-proof removable phosphor bronze bearings, ring oilers, safety toggle and simple hand wheel adjustment for setting the jaws to produce either fine or coarse crushed stone. Very simple throughout with only three bearings and all parts readily accessible and easy to install. Force feed action of the jaws insures maximum capacity. No expert help needed for operation.



Portable Outfits With Folding Elevator: The cut shows our standard mounting with folding elevator. The truck is of all steel construction and very strong. The "cut-under" feature makes this the most convenient and practical mounting on the market. Our largest machines with capacities up to 450 tons daily can be mounted in this style with folding elevator up to 25 ft. in length.

A very popular self-contained outfit complete with power is illustrated below. Always ready for work —no time lost in setting up. Ten sizes in this style.

Screens, elevators and conveyors built to meet individual demands. Details on request.



The Williams Patent Crusher & Pulverizer Co.

812 St. Louis Ave., St. Louis, Mo.

Manufacturers of Crushing Machinery

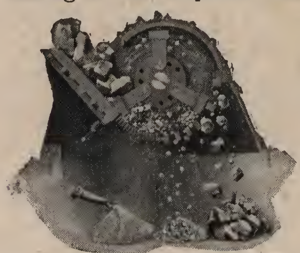
Chicago, 37 W. Van Buren St.
Philadelphia, 484 Bourse Bldg.
Scranton, Pa., 306 Coal Exchange Bldg.
Detroit, 420 U. S. Mortgage Bldg.
Pittsburgh, 201 Bowman Bldg.
Grand Rapids, Mich., 436½ Michigan Trust Bldg.
New York, 15 Park Row.
Dubuque, Iowa, 1022 Langworthy St.
Los Angeles, 523 S. Los Angeles St.
Seattle, Dexter Horton Bldg.
Denver, First National Bank Bldg.
Portland, Ore., 208 Porter Bldg.
San Francisco, 415 Fifth St.
Birmingham, Ala., 412½ N. 21st St.
Bristol, Tenn., 111 E. 5th St.
Kansas City, 417 Continental Bldg.
Houston, Texas, 1429 Allston St.
New Orleans, Woodward-Wight & Co., Ltd.

Products: Hammer Crushers for All Materials Including Crushers for Macadam, Concrete Stone and Rock Asphalt, Jaw Crushers for Gravel, Trap Rock.

Also Elevators, Conveyors and Screens. Complete crushing plants designed and equipped.

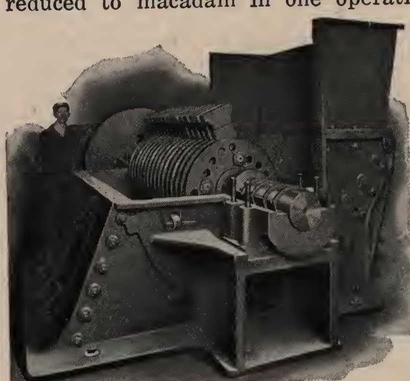
Williams — Original Patentees and World's Largest Builders of Hammermills — Patent Crushers Grinders Shredders

Crush larger rock—Make more uniform macadam—Smaller investment. By handling larger rock and reducing to the required size in one operation, one Williams hammer crusher will take the place of 2 or 3 other crushers. Fewer elevators, conveyors, screens and drives are required, smaller buildings suffice and investment needed for a Williams equipped plant is 50% less. Operating expenses are lower because the crushed rock is produced in fewer operations, less machinery is exposed to wear and tear and much power is saved by avoiding needless operations. Better size control and more uniform macadam is possible because of the hammer principle of crushing, which fractures the stone by impact and which can be adjusted to eliminate all pulverizing action. Macadam made with the Williams is unusually uniform in size. Contains a very small percentage of fines and is cubical in shape with no slivers to bridge and form air pockets in concrete.



Cross section of Williams Hammer Crusher showing how any size product can be made by using grates with larger or smaller openings.

The "Mammoth" Crushes Steam Shovel Size Rock to 1½". Rock as large as 48" cube is being successfully reduced to macadam in one operation with Williams "Mammoth" type crushers. This type is built in six sizes, the largest of which has a hopper opening 72"x52". Its hammers deliver 18,000 blows per minute, each blow 33 tons. Product can be adjusted as regards size and 3", 2" or 1" rock can be made with the same machine, simply by changing the grates.

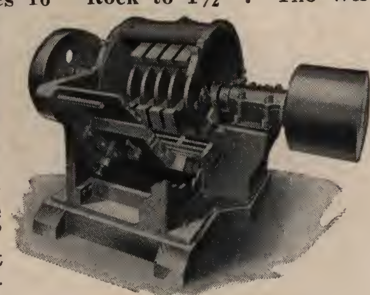


"Mammoth" crusher with cover removed.

One "Mammoth" crusher does the same work as a primary crusher and recrusher.

Portable Crushers. The "Jumbo Junior" type can be furnished complete with elevator all mounted on steel truck for use as portable crushing plant.

The "Jumbo" Crushes 16" Rock to 1½". The Williams "Jumbo" and "Jumbo Junior" types crush limestone as large as 16" and 14" to 1½", 1", or ¾", depending upon adjustment, in one reduction. The "Jumbo Junior" type is an excellent machine for moderate size quarries and will handle one man stone with ease. It embodies the adjustable breaker plate, adjustable hammers and interchangeable cage patented features and produces unusually uniform macadam. Indiana State Farm, Greencastle, Ind., says: "Makes best prepared stone State Highway Commission has used." Also adopted as standard equipment by the world's largest producers of rock asphalt. Twelve sizes of "Jumbo" and "Jumbo Junior" crushers.



"Jumbo Junior" Crusher.

"Jaw" Crushers. A complete line of steel and semi-steel Jaw Crushers is also offered for the reduction of gravel, trap rock and like hard material.

Williams "Portable" Hammer Crusher.

Complete Plants. We design and equip complete crushing plants. Detailed information, prices and printed matter gladly furnished. Write us.

BARBER-GREENE COMPANY

512 West Park Avenue, AURORA, ILLINOIS

Manufacturers of Standardized Material Handling Machines

REPRESENTATIVES IN 50 CITIES

Products: Self-Feeding Bucket Loaders, Portable and Permanent Belt Conveyors, Snow Loaders, Vertical Boom Ditchers, Car Unloaders, Coal Loaders.

Model "42" Bucket Loader: The Barber-Greene Model "42" has become standard for loading and batching aggregates on concrete and paving work. In addition it loads loosened subgrade—digs gravel directly from banks—handles coal and cinders—and does similar work at remarkably low costs.

Trucks can be loaded by this method at a minimum rate of 1¾ yds. per minute.

The patented disc-feed can be set to skim the ground so closely that clean-ups are unnecessary—or it can be set at an angle to dig the material from the bank. And the revolving discs dump a heaping load into every bucket.

An overload release spring protects the machine from damage when solid objects are encountered. And the floating boom keeps all shocks and strains from the loader frame.

Barber - Greene Strike-off Measuring Hoppers may be had for all B-G Bucket Loaders.

Model "25" Bucket Loaders: The Barber-Greene Model "25" Loader is identical to Model "42" except that it is smaller in size.

Model "28" Bucket Loaders: The Barber-Greene Model "28" is intended for light loading jobs that require frequent and rapid moves. It is the same as the Model "25" except that it is mounted on wheels instead of crawlers—either rubber tired wheels or plain steel wheels are furnished.

"N" Portable Belt Conveyors: Barber-Greene "N" Portable Belt Conveyors handle practically any bulk material such as stone, gravel, sand, wet concrete, brick, bagged cement.

They may be had in practically any length from 15 to 60 feet. The wheels swivel so that the material can be discharged in a semi-circle. And the height is easily regulated.

Power is supplied by a gasoline engine or by an electric motor.

"O" Portable Belt Conveyors: The Barber-Greene "O" Conveyor is the same as the "N" except that it has a cleated belt.

Permanent Belt Conveyors: The frame of Barber-Greene permanent belt conveyors is made up of standardized Warren Truss Sections. By adding or taking out additional sections any distance up to 300 feet can economically be reached.

"U" One Man Portable Belt Conveyors: The Barber-Greene "U" discharges at heights of from 5 to 12 feet. It is exceedingly low in price—$441.00 electric and $485.00 gas, and very desirable for light conveying work.

Snow Loader: The Barber-Greene Snow Loader replaces as high as 200 men in handling snow—and loading it into trucks or wagons. During the summer it can be converted into an efficient B-G Bucket Loader.

Vertical Boom Ditcher: The Barber-Greene Vertical Boom Ditcher is mounted on a compact, full length crawler chassis. The Vertical Boom slashes its way through coral rock, hard pan, sticky clay, caliche, brick and macadam pavement. And the patented Overload Release Spring prevents all damage when the digging boom strikes an obstruction.

For any trenching work 24 inches wide to 8 feet 3 inches deep, investigate Barber-Greene Vertical Boom Ditchers.

B-G Coal Handling Products: In addition to the machines mentioned above Barber-Greene manufactures a complete line of coal loading, unloading and handling equipment. Also a VIBRATING SCREEN for gravel and coal that vibrates at 1,000 v.p.m.

GEORGE HAISS MANUFACTURING CO., INC.

144th St. & Canal Place, New York, N. Y.

Cable Address
Coalhoist—New York

Manufacturers of Equipment for Handling Materials

Representatives in all Principal Cities

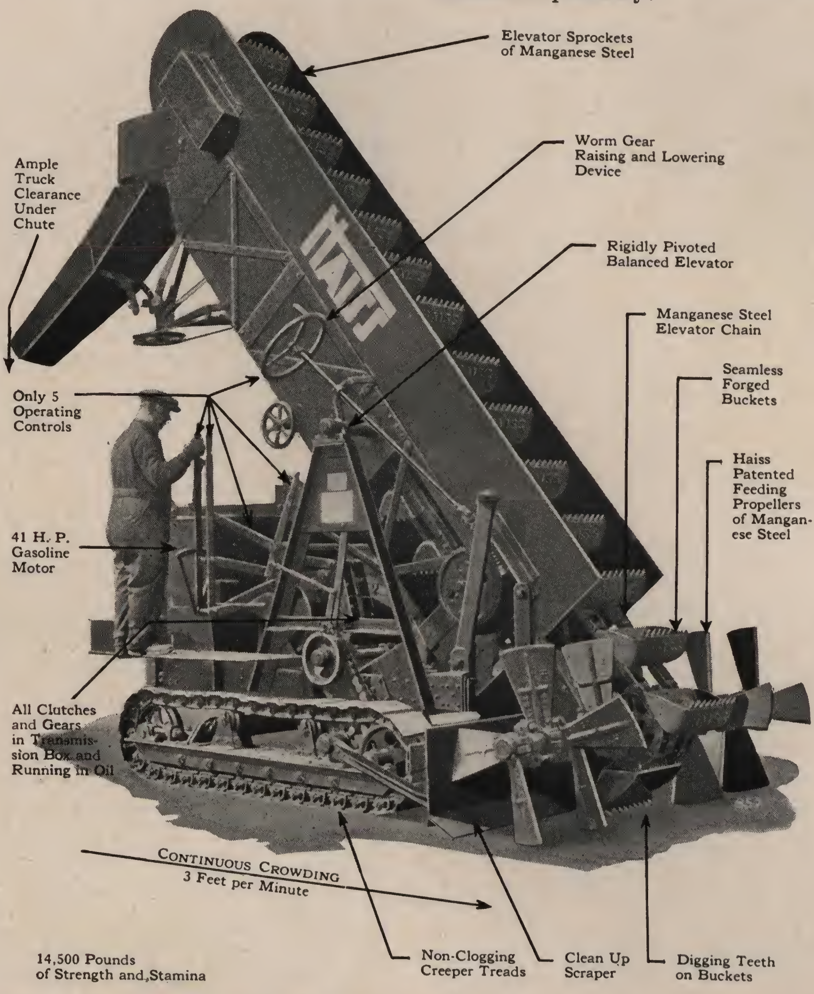
Products: TRUCK LOADERS, PORTABLE BELT CONVEYORS, SNOW LOADERS, CLAMSHELL BUCKETS, SCREENS, CHUTES, HOPPER GATES, ETC., FOR SAND, GRAVEL AND QUARRY PLANTS, ELEVATING AND CONVEYING MACHINERY.

HAISS

Experience and Service: Thirty-five years of specialization in mechanical equipment for material handling.

Pioneer builders of self-feeding and self-crowding loaders.

ing aggregates, grading streets, digging windrowed old macadam, taking up curing dirt, excavating soil, or digging in sand bank or gravel pit. Because of its weight, strength and power it has all-around ability, which makes it preferable to a lighter-built machine. The small difference in first cost is paid back not only in doing heavier work, but in lower upkeep costs on any work. The illustration herewith notes points of definite mechanical superiority:



The Company's special abilities in recommending the best organization of materials, handling work and the best economical equipment for doing it, are available through Company Offices and representatives—the nearest of which will be notified immediately your inquiry reaches us.

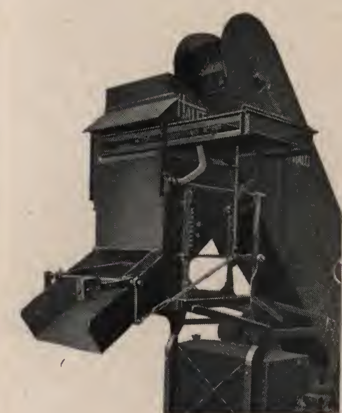
The Haiss "Creeper" Loader: This, the heavyweight of the Company's "Path Digging" Loaders, is the machine recommended for contractors' use—whether for batch-

Loader Capacity: 2 cu. yds. per minute with chute or swivel spout discharge—28E Paver batches at 37 second cycle (stone) and faster for sand. Hard work and heavy digging beyond that of any lower powered machine.

Widely Used: Haiss Loaders are working in every state where there is loader work. We will be glad to tell you where you can see one or give you the names of a list of users. Haiss Loader owner's experience is our best advertisement.

Continued on Next Page

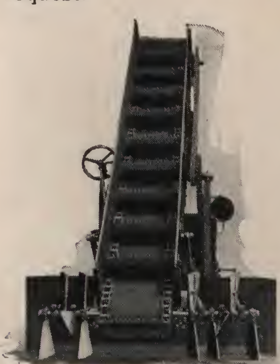
Model 16 Loader: This is a 1½ cu. yd. per minute machine for stockpile use. Powered with a 25 H. P. Waukesha motor and with Haiss Feeding Propellers and tooth-edged buckets it has the ability to rehandle sand, gravel, stone at high speed. It can be equipped with a Precision Hopper for batching. Complete specifications will be forwarded to those interested.



The Haiss Precision Hopper: For batching aggregates at advance stockpiles—and a batch hopper in which ease and micrometer accuracy of capacity-setting, speed of strike-off, quickness of discharge is just as much in a class by itself as is the Haiss Loader with which it is used. A size for sand and one for stone, each of adjustable capacity for all batch proportions.

The Haiss Loader and Precision Hopper have speed-loading capacity much in excess of a 27E Paver. You can lay pavement at top speed.

Two-Batch Hopper: The Company also furnishes 2 batch hoppers for high speed batching into 2-batch trucks. These double hoppers require mounting on a "Special 27" Loader with extra long caterpillars and heavier chassis. Illustrated literature will be sent on request.



Snow Loaders: A special-design flight or scraper conveyor on the standard Haiss Creeper Loader chassis—a Snow Loader which is rated at 5 cu. yds. per minute. It has standard Haiss feeding propellers and toothed flight buckets. It will dig in heavy snow, and in light fluffy snow will handle nearly double its rated yardage. Snow boom and bucket elevator are interchangeable and the machine may be changed over in spring and fall, and kept busy the year round. Catalog on request.

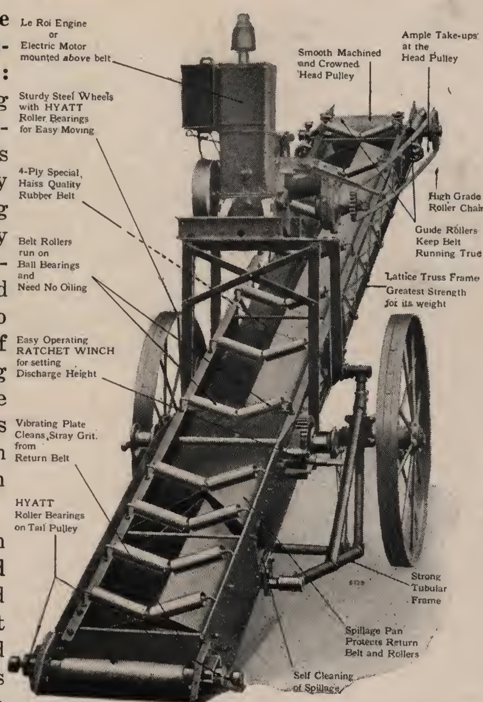
Haiss Clamshell Buckets: Husky, well-designed buckets in a range of types which meet every need with a bucket particularly suited to its work.

"Contractor" (Power Wheel) Buckets for speedy handling of crushed stone, sand, etc., at railroad siding, material yard or stockpile. Quick-action closing gear and quick-discharge bowl.

"Hi-Power" Buckets (Block and Tackle Type) for excavating and heavy digging—a bucket which wins on its work ability. Any ratio up to 7:1.

"Lever Arm" Buckets for work on which this type closing gear has the contractor's preference. Ratio 3, 4 or 5:1, depending on reeving.

In all types, electric steel top-edge reinforcing completely stiffens the bowls, while blade arms of electric steel and heavy connecting rods contribute strength to keep the jaws closing true in spite of abuse. Investigate Haiss Buckets.



Portable Belt Conveyors: Troughing type conveyor units for every contracting duty. They are designed and built to standard of engineering excellence that makes them worth more on any job. Made in standard 16, 20 and 24 in. belt widths and in lengths from 20 to 40 feet. A Haiss price quotation will convince you that you can afford a quality belt conveyor.

Brick Conveyors: Similar to Haiss (rubber) belt conveyors but with flexible wire mesh belt and spring-cushioned rollers (patents pending) to absorb loading shock. Used for bricks, cement blocks and other "sharp-corner" materials with thorough satisfaction. Catalog and list of users on request.

THE BURCH CORPORATION

Crestline, Ohio

Spreaders and Car Unloader

Products: Spreaders and Car Unloaders. **Burch Spreaders** will successfully spread stone, gravel, or slag by merely attaching them to truck and raising hoist and driving forward, depositing material evenly and reducing the cost by at least 75 per cent.

This cut gives a fair idea of the spreading and how it is done.

Spreaders are made in the following sizes:
Adjustable end spreaders 5′ 6″.
Adjustable end spreaders 6′ 6″.
Adjustable end spreaders 7′ 4″.
Adjustable end spreaders 8′ 0″.

Wing attachments for 12′ and 16′.

Spreaders are made for spreading asphalt also.

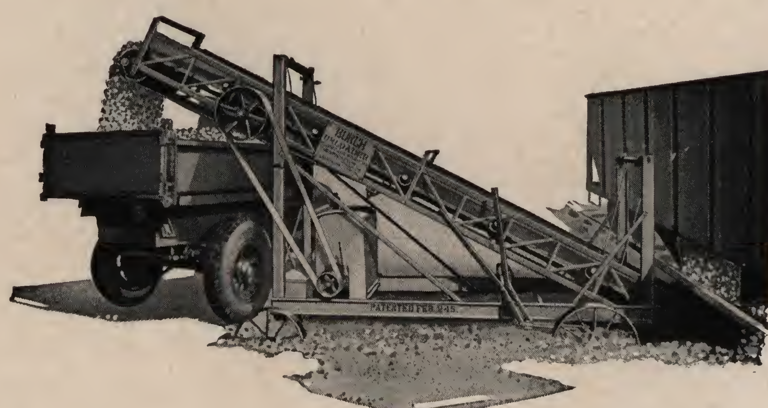
The Burch Car Unloader is one of the most economical machines to own and operate, requiring the service of but one man, and the capacity is far beyond expectation.

Quickly and easily installed and in every way most satisfactory. Will easily handle two yards of material per minute.

24 inch belt, equipped with LeRoi motor, with steel chute under track.

Always prepared to make prompt delivery.

Write for complete details as to construction and prices.



Equipment and Operation of Small Gravel Pits

H. J. Kuelling, Chief Engineer, Wisconsin Highway Commission, gives the following in *Roads and Streets:*

Many people view the subject of local material with suspicion. This is especially true of contractors who are not desirous of being loaded down with any more equipment or any more troubles. In Wisconsin, however, the contractors are gradually coming to look with favor upon this method of producing material, and there will be an ever increasing competition upon jobs where local material is available.

The writer frankly admits that commercial pits and quarries can produce cheaper than a temporary local plant and advises using them where the question of freight does not enter and the difference in truck hauls is not too great. However, as soon as freight on a railway enters into the argument, the handicap of 90 cts. to $1 a yard enters, a sum which alone more than covers the average production cost of the Wisconsin local pits.

Instead of the commercial companies sitting back and criticizing, the writer believes there is a good business opportunity for some of them to go into local production with one or more small outfits, such as will be described below. Plenty of business could soon be worked up for such an enterprising producer, as many contractors with no experience in aggregate production would be only too glad to hitch up with him.

Aggregate for 84 Miles of Concrete Road Produced Locally.—During the 1922 season there were constructed 355 miles of concrete road. Of these there were 187 miles on which the fine aggregate were shipped on a railway; 84 miles trucked or otherwise hauled directly from commercial plants; and 84 miles produced in local operation. In percentages these run 52.8 per cent shipped, 23.6 per cent trucked from commercial plants, and 23.6 per cent from local production.

In the matter of coarse aggregate there were 153 miles of which they were shipped on railways; 119 miles trucked from commercial plants, and 83 miles produced in local operations. In percentages these are 43.1 per cent shipped; 33.5 per cent trucked from commercial plants, and 23.4 per cent produced locally. Analyzing these on a basis of 2 coarse to 1 fine aggregate, it is readily seen that 54 per cent of the tonnage on these 355 miles of paving never saw a railway. Naturally, this means cheaper concrete roads, a saving in freight, easing up on the burden of the railways, a saving in bond cost, and an easing up for the contractor in the all important matter of financing his job.

Test Pitting Site of Gravel Deposit.—The test pitting is an exceedingly important feature of the work. It must be done extensively and thoroughly. The methods involved and the extensiveness, of course, varies with the kind of material being searched for. If several miles of concrete road are to be built out of a proposed pit, it is necessary to very thoroughly test pit the site, especially if it is an undeveloped deposit. Enough holes should be dug to determine the extent and they should be dug to an adequate depth to determine the working face. We have dug holes 30 ft. and over by using box sheeting of 2-in. boards 4 ft. long dovetailed at the ends. It is an easy matter to construct a windlass operated by hand, and with a hole 4 ft. square a pretty good sized bucket can be attached for raising the material out of the opening. The samples for testing purposes should be taken at the time of digging. Our requirement for such purposes is a representative sample of 500 lb. of pit run material from the deposit. The samples should not be taken from one hole, but from several different holes. Probably the best method of handling the samples is to sack the material in cement sacks. Tags are filled out and one placed inside the sack and one attached, after which they are sent express or freight collect to the laboratory at Madison. The man supervising the work also fills out an aggregate sheet furnished by the commission describing the deposit, which sheet he sends direct to the materials department. Here a duplicate is made and sent to the laboratory and the original kept in the files.

From these samples tests are made, both on the fine aggregate and the coarse. Sand briquettes are made for breakage at three, seven and ten days. Coarse aggregate is tested in specimens 18 in. long, 8 in. in width, and 4.3 in. in thickness. These are always made at the same time as specimens of standard material. Both are tested at the same time in a rattler and later in tension and compression. By always running these tests with a standard, we not only can compare the material with the standard, but with any other.

The information thus obtained is placed in the hands of prospective bidders through the medium of the district offices. The cost of testing material from one deposit is estimated to be about $35. If a prospective bidder is still not satisfied he may make an investigation of the material himself, and should, by all means, make a most careful investigation of all the physical features surrounding its use, such as water supply, topography, soil, roads, etc.

Of course, no proposed gravel pit can be guaranteed to be absolutely safe. By this we mean that even with the best kind of test pitting a few pits when opened up disclosed objectionable features which were not apparent before. These features may be enumerated as a pit running to sand, too many oversize boulders, and a pit containing heavy seams of clay. These failures, however, are few, and often where there has been a failure some bit of negligence or ignorance was responsible for it.

For instance, in one case the proposed deposit was thoroughly test pitted, but in setting up the plant it was moved just a little north along the ridge from where the test holes had been. When the ridge was opened they encountered huge bolders and had to change the dragline to a steam shovel. The boulders had not shown up in the test pitting and, in fact, the south side of the pit, which was the side nearest the test holes, showed hardly a boulder. Another case was that of a deposit not recommended by the state, but one which the contractor was eager to set up in. Consequently, while a small pit was showing in a ridge it was never thoroughly test pitted. The result was disastrous as the contractor was ordered to shut down when it was found that the material was running out, and also was becoming too dirty to use for concrete. Another case was that of a perfectly good pit, but wherein inadequate machinery was placed. The contractor placed a small movable outfit in this pit to produce concrete aggregate. The bin capacity was only 18 yards. While the pit run material actually ran 50 per cent sand and 50 per cent stone, the plant was too small to handle the waste sand successfully, with

the result that it was an absolute failure and was forced to quit right at the start.

The Gravel Pit.—The production of concrete aggregates by means of a local plant is a problem of some magnitude. In the first place, let it be said that a plant for this purpose must be stationary. Another good feature of the successful plant is adequate bin capacity, for if there happens to be a temporary breakdown in the pit operating machinery and the bins are pretty well filled up, the trucks or other hauling equipment is still able to operate. Of course, the entire equipment must be efficient and efficiently operated as well. Too small a crusher or screens, not enough horsepower, poor management, and a poor pump in case of washing, are some of the objectionable factors in a plant not operating efficiently. The contractor in choosing his setup and machinery has quite a problem on his hands. He should look the proposed site over well and take all the factors into consideration. He must consider the distance he is to be from the project and also what method of hauling and charging the mixer is to be used. Of course, the problem of set-up does not always rest with the contractor, as there are quite a number of cases where the county has owned and operated a pit, supplying material for its own day labor crew, or else furnishing material to a contractor at a much lower price than he could purchase it from a commercial concern.

Cost of the Plant.—A well built and efficient gravel plant for producing satisfactory aggregates for concrete pavement construction should cost in the neighborhood of $10,000 to $12,000, including the items of erection. The reasons for a variance between the above mentioned figures in the difference in cost between a washing and dry screening plant, freight, erection, etc. A plant of this price has a bin capacity of about 200 yd., which ought to be sufficient. Below is a table showing the approximate cost of a stationary, up-to-date gravel plant:

Crusher	$ 2,800
Grizzly screen	50
Blade feeder	300
Cables, shieves, etc.	300
Hoist	1,000
Dragline bucket	450
Two 60 h.p. motors	2,200
Elevator	500
Screens	400
Lumber for bins, etc.	1,000
Cost of erection	1,000
	$10,000
Cost of washing equipment	$ 700

Another item which is really an extra is the measuring device. Where batch trucks, for instance, are to be used, this is an absolute necessity. There have been attempts to construct home-made devices with mediocre success. There are mechanical devices on the market which are quite successful. They are, however, pretty expensive, as an outfit costs about $500.

Description of a Contractor's Plants.—Two plants of one contractor are identically alike, and while not absolute models of perfection, are worthy of description. An arrow shaped dragline bucket handling about a cubic yard at a time pulls the material up, where it is dumped through a trap onto the blade feeder. This feeder is in the form of an endless belt which has a number of blades fastened thereon. This turns slowly and constantly dumps the material onto the grizzly screen. Thus the material is fed gradually to the crusher while the dragline is making its return trip. The rejected gravel from the grizzly drops into a No. 4 gyratory crusher set at about 1½ in. Then the material is carried up to the screens in a bucket elevator about 50 ft. high and containing approximately 140 buckets. The screens are of the revolving type, 4 ft. in diameter and in sections. The first section is 6 ft. with a ¼-in. round opening, the second 4 ft. with a ¼-in. round opening, and the third 6 ft. with elliptical opening ¼ in by 1 in. in size. For dry screening a screen of the last section type is probably the best. However, the last section of screen should have 2 in. round openings to take care of any oversize material. A chute could be built from the end of this screen back to the crusher. It has also been found very necessary at times to insert a section of ½-in. round screen to waste the pea gravel sizes when the gravel in the deposit runs fine. Two 60-h.p. motors furnish the power for operating this plant. One takes care of the blade feeder, crusher, elevator and screens, and the other the double drum hoist operating the drag line. The bins for this plant are 11 ft. wide, 36 ft. long and 14 ft. deep. They are set on a concrete foundation 38 ft. long with a base of 3 ft. and tapering up to 16 in. The horizontal timbers resting on this concrete foundation and supporting the uprights are 10 in. by 12 in. The uprights themselves are 10 in. by 10 in. and 12 in. by 12 in. Seven 10 in. by 12 in. timbers are used as braces for the uprights. There are also 14 cross braces 6 in. by 8 in. in size, seven on each side; 2 in. by 12 in. are used as floor joists spaced with 6 in. centers. There is also cross bracing on the side of 3 in. by 12 in., two being used together making six pairs on each side. The floor and sides of the bins are of 2 in. by 12 in. planks, the studding being the same size as the floor joists. They are double rodded, the long rods being 1½ in. in diameter and the short ones 1⅛ in. The bin supports or whales through which the rods are bolted are 6 in. by 12 in. doubled. These hold the whole bin together and there are three tiers of them, the first 1 ft. above the sill, the second 4 ft., and the third 10 ft.

Arrangement for Washing.—A large proportion of local pits contain enough dirty material to require washing. There is also something in the proposition of expediting the work of the screens by washing, especially on damp days. A number of different types of washers are used. Probably the most common is that of old tilting box type, with which nearly every one is familiar. The valve control or discharge for the washed sand in this type is dependent of operation upon the weight of the sand contained in the settling tank. There are a few mechanical objections to a washer such as this. First, the inertia of so great a weight makes the valve action slow, so that with uneven feeds the valve does not always close in time to prevent a "runaway." Secondly, a tank of this sort is operated by balanced weights which to operate quickly must be set so that the valve does not close tightly when the feed of sand ceases, but while the water is still coming. Sometimes, unless the valve is closed by hand, an amount of water and clay gets into the clean sand already discharged.

There are also steel conical tanks on the market which are quite expensive, but more efficient, as the discharge is controlled by volume rather than by weight.

A good many pit operators are using a washer of a different type. This is really a mechanical conveyor sort of settling tank. It consists of a large rectangular

wash box of wood, with a discharge for clay and dirty water at one end. The floor of this box slopes upward at the other end to the top. A number of blades are fastened to an endless chain which operates over sprocket gears at either end of the box. These blades dip down into the water, and, by close contact with the slanting floor, carry the washed sand to the top, where it is dumped over into the bins. There is a space at either end of each blade which permits excess water to return to the tank. These blades continually agitate the dirty water in the tank and keep the dirt in suspension until it is carried off over the spillway. Plenty of clean water must be poured into the tank continually, and it is well to have several sprinklers playing on material as it is pulled up to be dumped into the bins. These washers are sold in two sizes, 4 ft. by 18 ft. and 3 ft. by 18 ft., respectively, and are priced at about $500, exclusive of any wash box lumber. The former size has a capacity of 40 tons of sand per hour, and the latter 35 tons.

Any of these washers, of course, are for sand only. It is sometimes, and, in fact, always, just as necessary to cleanse the gravel. For this a water pipe with an end spray can be discharged into the screens. This will aid very materially in pushing the sand through the sand screen into the settling tank, and also for separating the sand from the stone when it has a tendency to stick together in damp weather. It is also advantageous to have a section of closed screen containing angle irons bolted to the sides, which may be termed a scrubbing chamber. One of the principal requisities for a successful washing plant is plenty of clean water. Four-inch pipe should be used, if possible, and a pump powerful enough and an adequate water supply to produce 250 to 300 gallons a minute is necessary.

Savings from Use of Local Material.—From one pit about 6.53 miles of road were built. The total job was 7.29 miles in length or 77,176.4 sq. yd. of paving. The low bid on this was $1.07 per sq. yd., exclusive of cement, as against the lowest bid for commercial material of between $1.12 and $1.16. This is a difference of about 7 cts. per sq. yd., or a total saving of $5,402 on the entire job. However, the facts that the pit was easily obtainable and a good set-up, that the hauls were good, and that several contractors were interested who wished to go into their own material production, all had a tendency toward producing one of the lowest bids per square yard in the whole state.

Another job consisted of about 8 miles of 18-ft. paving, the low bid being $1.19 per sq. yd. and the lowest bid per square yard using commercial material was $1.49, or a saving of 30 cts. per sq. yd. This meant a saving of approximately $25,344 on this one job. The plant was equipped with a hoist and upright boiler, arrow scraper, one 60 h.p. motor, a loader elevator, a bucket elevator, old style washing plant, screens and 160-yd. capacity bins. Provision was made to chute the rejected oversize stone back into the pit. From this plant approximately 25,400 cu. yd. of sand and gravel were hauled out on the road. This meant an average of about 250 yd. a day on the road and does not include an average of about 20 to 25 yd. of material wasted each day. Material was hauled in trucks onto the road and stock piled every thousand feet. From the stockpiles a fleet of Ford batch trucks carried the aggregate to the mixer.

Another road, 3.3 miles in length, was constructed, the low bid being $1.29 per sq. yd., using local material. The lowest price bid per square yard using commercial material was $1.45, a saving of 16 cts per sq. yd. This means a saving of $5,575 on the entire job. The material was trucked onto the roadbed, stock piled and wheelbarrows used to charge the mixer. This was the second season that the contractor had operated this pit.

Another job of 4 miles was partly constructed, about 3½ miles being built. The bid per square yard using local material was $1.11, whereas the lowest bid per yard using commercial material was $1.35, or a saving of 24 ct. a sq. yd. This is a saving of $10,137 for the entire job. The material was hauled on the road, stockpiled, and wheelbarrows used to charge the mixer. They had about 6,000 yd. of material stockpiled on the subgrade before the actual paving work started. The equipment at the pit consisted of a bottomless drag line bucket, a plate feeder, a conveyor, a 9 in. x 15 in. jaw crusher, grizzly, a 36 ft. bucket elevator, a tilting box type washer, screens and bins, a 60 h. p. tractor, a double drum hoist and upright boiler, a 19-20 tractor, and a centrifugal pump. The bin capacity was small, holding only 90 to 100 cu. yd. Provision was made to chute the oversize stone back to the crusher. The 10-20 tractor furnished power for the pump which had a capacity of 450 gal. a minute, but only about 300 gal. a minute were actually used. The production of this plant was small as it averaged only about 150 cu. yd. of sand and stone to the road per day. The smallness of the crusher was greatly to blame for this as the 9 in. x 15 in. jaw crusher was only capable of a capacity of about 10 to 15 cu. yd. an hour. What they should have had in its place was a gyratory crusher, No. 3 or 4 in size. The bin capacity was small and the whole plant was not constructed in as stable a manner as possible, probably accounting for the numerous delays and breakdowns.

County Operation of Local Plant.—One county operated two local plants. One contractor built about 40,634 sq. yd., using material from one of the county pits. His price for this of $1.16 sq. yd. was based on material at $1 per cu. yd. in trucks at the pit. This material had he shipped it in would have cost him $2.18 per cu. yd. for gravel and $1.90 per cu. yd. for sand in trucks at the destination. The comparative hauls were about the same.

The other county pit kept two pavers going and about 8 miles of road were built using this material. It is rather difficult to get at the saving involved here as the contractor's bid did not include a material price, this being furnished him by the county. The county highway commissioner, however, believes that material was being produced in stock piles for about 70 ct. a yd. Shipped-in sand and stone would have cost $2.03 and $2.20 per yd., respectively, unloaded in stock piles or bins. As 26,000 cu. yd. of sand and stone were used in building the road it will be seen that considerable saving was involved (at least $30,000) by developing a local pit.

Both of these county plants used wash-boxes. Each plant was equipped with a stiff-leg derrick and bucket. The material as it came from the screens was loaded into a large stock-pile. From here it was transferred into the big measuring hoppers and loaded into batch-trucks.

SAUERMAN BROS., INC.

482 S. Clinton St., Chicago, Ill.

Manufacturers of Cableway Excavators and Power Scrapers

Products: SLACKLINE CABLEWAY EXCAVATORS, POWER DRAG SCRAPERS, CABLEWAY AND SCRAPER HOISTS.

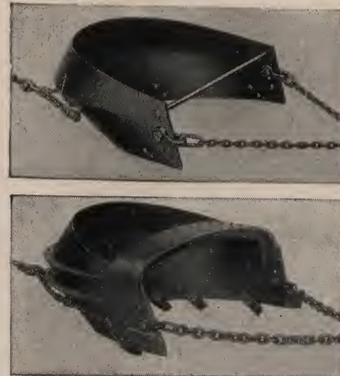
Sauerman Slackline Cableways are the most practical and economical machines to use for digging sand and gravel from a river or pit, because they will reach out a great distance (as far as 1,200 ft., if necessary), dig to the full depth of any deposit, and lift the material to the top of a screening plant or high storage pile.

Sauerman slackline buckets range from ⅓ to 3½ cu. yd. in size. The hourly handling capacity of each size of bucket will vary in accordance with the length of span over which it is operated. The maximum capacity of a 3½-yd. Sauerman Slackline Cableway is 200 cu. yd. per hour. Larger sizes than this are built to order.

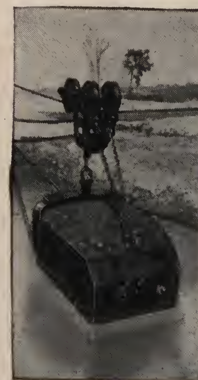
"Junior" Slackline Cableways are semi-portable units, particularly suitable for contractors' use. These machines are made in three sizes with buckets of 6, 9 and 13 cu. ft. capacity respectively. The standard operating span for all three sizes is 300 ft. Power is supplied by gasoline engine, electric motor or belt drive.

Sauerman Power Drag Scrapers are recommended for excavating bank deposits of gravel, stripping overburden, making cuts and fills, storing and reclaiming loose materials. In comparison with the yardage they will handle, Sauerman Scrapers cost relatively little to install, operate and maintain. The most common operating spans are 300, 400 and 500 ft.

"Crescent" bottomless buckets, which are an exclusive feature of



Two Views Showing Design of Small and Large Sauerman Scrapers



Cableway Bucket Rising From Pit

Sauerman power scraper equipment, are built in sizes from ¼ to 10 cu. yd. This provides a range of sizes that meets the capacity requirement of every excavating job, no matter how small or how large.

Sauerman Portable Scraper Outfits are made in four sizes: ¼, ½, ¾ and 1 cu. yd., capable of handling respectively 12, 25, 40 and 55 cu. yd. per hour. Operating span, 200 ft. Designed for contractors who demand a compact excavating unit easily moved from job to job.

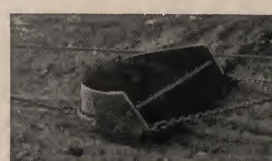
Typical 500-ft. Span Wet Pit Cableway Installation

Cableway Loading Pit-Run Gravel Into Cars

Scraper Cutting Down Hill and Filling Ravine

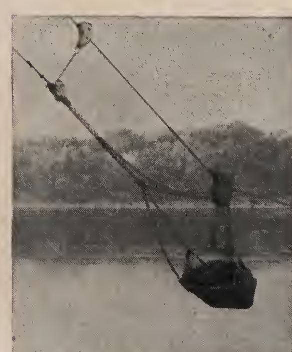
How Gravel Plant Makes Use of Sauerman Scraper

Example of Deep Digging by Sauerman Cableway



Close-up View of Scraper Stripping Overburden

"Junior" Cableway, Operated by Tractor, Producing Gravel for Road Maintenance Work in Indiana



Cableway "Dipping" Gravel From Bed of River

Water Supply in Concrete Road Construction

Pumping Data

From the Pumping Guide of the Domestic Engine & Pump Co.

How to Determine the Power Required for Pumping.—The power required for pumping depends primarily upon two factors—the weight of liquid to be pumped per minute and the vertical height it has to be raised from source of supply to the point of delivery. In addition to these two principal factors, allowance must be made in practice for the losses in the pumping equipment and the friction in the pipe lines.

A practical formula in common use for determining the H. P. required for pumping water is:

$$\frac{\text{G. P. M.} \times \text{H.}}{4{,}000 \times \text{E.}} = \text{H. P.}$$

G. P. M. = Gallons of water per minute.
H. = Total working head.
E. = Efficiency of the pump and gearing, expressed as a decimal.

ILLUSTRATION: We wish to pump 30 gal. per minute. The distance from source of supply is 1½ miles to discharge point, and the highest point of elevation from surface of water at source to discharge point is 70 ft. Our pipe line will be 2-in. pipe, and we need 8 ninety-degree elbows in the line. What horsepower engine should we use?

From table of friction of water in pipes we get the following:

Added friction head in each 100 ft. of 2-in. pipe discharging 30 gal. of water per minute = 2.09 ft. For 7,920 ft. = 79.2 × 2.09 = 165.53 ft. (if old rough pipe is used add 30%).

From table Friction in Elbows, we get:

Added friction head for each 90 degree elbow, 2-in. size, discharging 30 gal. per minute = .127 ft. Eight elbows = 8 × .127 = 1.016 ft.

The total working head, therefore, is 70 + 165.53 + 1.01 = 236.54 ft.

The efficiency for the average small force pump is 50%. Substituting these values in our formula

$$\frac{\text{G. P. M.} \times \text{H.}}{4{,}000 \times \text{E.}} = \text{H. P.}$$

we get

$$\frac{30 \times 236.54}{4{,}000 \times .5} = 3.54 \text{ H. P.}$$

Wrought Iron or Steel Pipe

Full Weight—Black and Galvanized, for Steam, Gas and Water. Standards Adopted January 1st, 1913.

Size	Diameter		Thickness	Weight per ft., lbs.		Threads per Inch
	External	Internal		Plain Ends	Threaded & Couplings	
2	2.375	2.067	.154	3.652	3.678	11½
2½	2.875	2.469	.203	5.793	5.819	8
3	3.500	3.068	.216	7.575	7.616	8

The permissible variation in weight is 5% above and 5% below. Pipe smoothed on inside is known as Reamed and Drifted. Extra Strong and Double Extra Strong Pipe both have the above given External Diameter but have smaller Internal Diameter.

Table giving the friction head in feet for each 100 ft. in length of clean, straight iron pipe, discharging given quantities of water per minute

Gallons per Minute	Size of Standard Iron Pipe		
	2-in.	2½-in.	3-in.
25	1.43	.485	.231
30	2.09	.693	.300
35	2.76	.92	.393
40	3.68	1.19	.53
45	4.60	1.49	.647
50	5.61	1.86	.80
60	8.88	2.70	1.15
70	11.09	3.46	1.385
80	14.55	4.63	2.08
100	21.75	7.36	3.01
125	34.27	11.24	4.57
150	48.76	16.10	6.55
175	....	21.75	8.85
200	....	28.68	11.54
250	....	....	17.84
275	....	....	20.09
300	....	....	25.76

Table giving the friction head in feet for each elbow used in line of pipe discharging a given quantity of water per minute

Gallons per Minute	Size of Standard 90-Degree Elbows		
	2-in.	2½-in.	3-in.
25	.087		
30	.127		
35	.175	.085	
40	.226	.049	
45	.288	.143	.059
50	.353	.185	.074
60	.507	.258	.101
70	.701	.341	.138
80	.925	.452	.184
100	1.412	.738	.295
125	2.24	1.175	.462
150	3.205	1.58	.659
175	....	2.16	.899
200	....	2.955	1.18
250	....	....	1.845
275	....	....	2.35
300	....	....	2.63

When Pipe or Elbow is slightly rough add 15%.
When very rough add 30%.

Theoretical Discharge of Nozzles in U. S. Gallons per Minute

Head		Diameter of Nozzle in Inches				
Pounds	Feet	½-in.	⅝-in.	¾-in.	⅞-in.	1-in.
10	23.1	23.6	36.9	53.1	72.4	94.5
20	46.2	33.4	52.2	75.1	102.	134.
30	69.3	40.9	63.9	92.	125.	164.
40	92.4	47.3	73.8	106.	145.	189.
50	115.5	52.8	82.5	119.	162.	211.
60	138.6	57.8	90.4	130.	177.	231.
70	161.7	62.5	97.7	141.	191.	250.
80	184.8	66.8	104.	150.	205.	267.
90	207.9	70.8	111.	160.	217.	284.
100	230.9	74.7	117.	168.	229.	299.
125	288.6	83.5	130.	188.	256.	334.
150	346.4	91.5	143.	206.	280.	366.
175	404.1	98.8	154.	222.	302.	395.
200	461.9	106.	165.	238.	323.	423.

NOTE—With smooth taper nozzles the actual discharge is about 94% of the figures given in table.

Number of Feet to be Added to Lengths of Straight Pipe for Each Globe Valve

Size Globe Valve threaded for pipe........	2-in.	2½-in.	3-in.
Added feet due to friction........................	8	12	24

Quantity of Water and Size of Pipe

Extract from an article, "Efficiency in Concrete Road Construction," by J. L. Harrison, Highway Engineer, U. S. Bureau of Public Roads, in the January, 1926, issue of Public Roads

The water used in mixing—and in curing as well—is as truly one of the materials entering into the construction of a concrete pavement as are cement and stone. With the water, as with the stone or the sand, methods of handling and means of delivery are vital factors in efficiency. Only one system of handling water is in common use today. It is pumped through a pipe line laid along the right of way to the mixer. In the common practice provision is made at regular intervals—generally 200 to 300 ft.—for taking water from the pipe line, and a hose connection is used to feed the mixer. These hose connections are also used to obtain water for sprinkling and for any other job requirements. A study of the "lost time" on the job will show that the time lost as a result of trouble with the water supply is rather a large item. There is, then, ample justification for an analysis of the methods and equipment in use, for it is quite as essential that the water supply equipment shall be adequate as that the truck supply shall be adequate. Probably from the engineering standpoint it is more important, for, while production is somewhat affected by current practices, quality probably is more affected.

Basically, the water trouble on almost all concrete jobs today is inadequate water delivery facilities. With full production, a batch is produced every 1¼ minutes. Few jobs, it is true, maintain this rate consistently

over any extended period, but a good many reach it not infrequently for a few minutes at a time. This rate, then, sets the water delivery rate. At least ¼ minute is required in discharging the measuring tank. A full minute is, therefore, all that can be allowed for the delivery of the water for a batch of concrete. A 1-in. slump normally requires between 5 and 6 gals. of water per bag of cement—roughly 30 gal. per standard batch which, under the assumptions made above, is equivalent to 30 gal. a minute. In addition to this, water is required for curing. With full production and a 10-day curing period it will be necessary continually to provide for curing nearly 2 miles or about 20,000 sq. yd. of paving. Rates of production as high as this are rare, but rates of production which will require the proper care of at least 15,000 sq. yd. of paving though not the rule are not uncommon. To cure concrete properly requires that the earth covering shall be kept moist—not merely that it shall be wet down once in a while; and rates of evaporation from loose soil, such as that used for covering the pavement during the curing period, are high. In fact, the evaporation from such soil when the temperature is high, the humidity low, and a brisk breeze is blowing—typical summer conditions over the greater part of the United States—will often exceed 1/3 in. per day and may even exceed ½ in., equivalent to from 2 to 3 gal. per square yard of pavement. These are, of course, the highest rates of evaporation likely to be met but as it is at just these times that full protection of the pavement is most required, they must be considered the governing rates.

Finally, the contractors properly prefer to conduct all their operations simultaneously. For that reason, though night sprinkling may at times be practiced, the contractor generally desires to attend to it during the day as the work is then under the observation of his regular foremen. The inspector also has a better grasp on the situation if it is done at that time, and, of course, during very dry weather a night wetting is not sufficient to keep the pavement moist throughout the following day. It is, therefore, proper to view the pavement-curing problem as one which under full production may involve the daily delivery of from 40,000 to 60,000 gal. of water in addition to mixer requirements and even under normal current production standards the daily delivery of from 30,000 to 40,000 gal. of water in excess of mixer requirements.

As shown above, full production at the mixer requires for mixing the concrete a somewhat variable amount not ordinarily exceeding 15,000 gal. per day. For current high rates of production at the mixer the requirements of the mixer seldom exceeds 12,000 gal. a day (10 hours). To these amounts there must be added a somewhat variable amount for wetting down the subgrade. It is therefore apparent that while a pump capable of delivery 100 gal. per minute has sufficient capacity to meet all needs that will ordinarily arise until the production of 18-ft. pavement exceeds 750 ft. a day, it is apt, at times, to prove inadequate where more than this amount of pavement is being produced unless it is worked a few hours overtime.

One thing, however, must be emphasized—namely the adequacy of the pumping plant depends absolutely on the use of a pipe line of such size that the pressure head will always be within the limits for which the pump is designed. There are vital differences between a pump designed to deliver 100 gal. a minute against a pressure head of 100 lb. and one designed to deliver at the same rate against a pressure head of 400 lb. This raises the question as to what pressure head is required in delivering water. Table I gives the pressure head in pounds for various rates of delivery in gallons per minute, per mile of common iron pipe such as is generally used on paving jobs and while the pipe is in fair condition. As the pipe becomes somewhat battered, twisted, and rusty with use, the pressure head required to force water through it will increase so that, in a general way, the figures given are minimum figures, which may be exceeded somewhat after the pipe has been in use a few years.

The pressures given in the table are the number of pounds, as read on the gauge at the pump, which will be required to deliver the stated number of gallons per minute at the outflow end of a pipe line 1 mile long. Thus, if 50 gal. per minute are required and a 2-in. pipe a mile long is to be used, the gauge at the pump must be run up to 227 lbs. If 100 gal. are desired 1 mile from the pump and a 2-in. line is used, the gauge pressure at the pump must be run up to 820 lb., and if this rate of delivery were required 3 miles from the pump the gauge pressure would have to be run up to 2,400 lb. Of course, neither ordinary pipe nor ordinary pumps will stand any such pressures. The point, however, is that here is the explanation of the poor water supply so common on paving jobs today. Contractors are attempting the impossible. A fully adequate water supply for maximum requirements simply can not be driven through a 2-in. pipe 2 or 3 miles long. If the pump were strong enough to do it, the pipe would not stand it. The remedy lies in a larger pipe. One hundred gallons of water per minute can be driven through nearly 2 miles of 3-in. pipe with the same gauge pressure—i. e., the same effort on the part of the pump—which is required to drive it one-quarter mile through a 2-in. pipe.

With no other consideration than the water supply for the mixer, contractors could well afford to use 3-in. pipe, for its use would result in a water delivery at a pressure far less destructive of pumps, line, hose, mixer valves, etc. The added cost of pumping enough for adequate curing and, subgrade sprinkling would be so slight that the problem would cease to be troublesome.

In addition to reducing lost time at the mixer, the installation of the 3-in. pipe would permit the use of relief valves which would protect the pipe line, hose, and mixer valves against excessive pressure. Gauges should also be installed at the pump, and instead of permitting pumps to run wide open their speed should be controlled according to the rate of delivery desired and the distance this delivery must be pumped. Thus, as an illustration, if the maximum water requirement is 60 gal. per minute through 2 miles of 3-in. pipe line, the pumping engine should be cut down to a speed which will produce a pressure of about 150 lb. at this delivery. The relief valve at the pump should then be set at slightly above this pressure, while the relief valve at the mixer might be set at 50 lb. or even less. This practice saves wear and tear on the pump and tends to avoid the breakdowns which occur most frequently when machines operate close to or above rated capacity.

Table I.—Pressure required at pump for each mile of pipe line to secure desired discharge, through 2, 2½ and 3 in. ordinary iron pipe*

	Number of gallons to be pumped per minute, or per 10-hour day													
	20	25	30	35	40	45	50	60	70	80	90	100	110	120
Diameter of pipe	12,000	15,000	18,000	21,000	24,000	27,000	30,000	36,000	42,000	48,000	54,000	60,000	66,000	72,000
	Pressure required at pump, pounds per square inch													
2 in.	42	62	88	117	151	188	227	318	421	543	673	820	982	1,145
2½ in.	14	21	30	39	50	62	76	106	142	181	224	275	330	385
3 in.	6	9	12	16	21	26	32	44	59	75	93	114	137	161

*Based on Williams and Hazen's hydraulic tables.

NOTE—To obtain the total pressure against which the pump must work, multiply the figures given in the table beneath the desired gallons per minute and opposite the desired diameter of pipe by the total length of the pipe line in miles and then add to this product the figures obtained by multiplying the use of the pipe line in feet from the pump to the discharge end by 0.434.

Water Required for Concrete Paving

The State Highway Department of Pennsylvania compiled the following information for use in determining the sizes of pipe line to be used for the water supply on concrete paving projects. The information is based upon 50 per cent of the water being required for curing and 50 per cent being required for the mixer and subgrade curing. The department states that if calcium chloride is used for curing the amount of water required for the lengths paved per hour can be reduced one-half.

The tables given under the sizes of pipe lines are figured without modifications for head, and the table at the bottom of the tabulation gives the information for the correction for the head.

The tables are based on a requirement of 8,000 gal. of water for 100 ft. of paving apportioned as follows: ½ for curing, ¼ for subgrade, ¼ for mixer. The pavement is assumed to be 18 ft. wide. The head given is based on friction loss only. To this must be added the height of the outlet of the pipe above the source of supply.

How the Tables Are Used—Example (1):

Estimated progress of paving 70 ft. per hour. Water required—5,600 gal. per hour.

Maximum water pressure in pump—150 lb. per square inch.

Pipe 2-in. diameter, pump 12 ft. above level of supply. Outlet 40 ft. above pump.

How far from the pump can the work be supplied?

150 lb. pressure=345 ft. head as per conversion table. 345—12—40=293 ft. net head.

The head required for 1 mile of pipe is 1,083 ft. Distance water can be supplied$=\frac{293}{1083}=$¼ mile.

Example (2):

Estimated progress of paving—70 ft. per hour.

Maximum water pressure in pump—500 lb. per sq. in.

Maximum distance water must be forced=2½ miles.

What size pipe is required?

500 lb.=total water pressure available, which corresponds to 1,152 ft. head.

2-in. pipe under these conditions required 2,708 ft. head or 1,175 lb. pressure and is too small.

2½-in. pipe is necessary and requires 1,116 ft. head, which corresponds to 484 lb. pressure.

A 3-in. pipe requires 377 ft. head which corresponds to 163 lb. pump pressure.

Example (3):

Estimated progress per hour=90 ft.

Distance water must be forced=2½ miles. What horsepower and pressure are required?

2-in. pipe requires 4,333 ft. head by table or 1,880 lb. pressure.

Water required=7,200 gal. per hr.=2 gal. per sec. =16.7 lb. per second.

16.7 by 4333=72,360 ft. lb. per sec.÷550=132 horsepower.

2½-in. pipe would require 1,785 ft. head by table or 775 lb. pressure.

16.7 by 604÷550=18 horsepower.

3-in. pipe would require 604 ft. head by table or 250 lb. pressure.

16.7 by 604÷550=18 horsepower

Water Supply Data

Loss of head due to friction in steel pipes for water used in paving

Length Paved Per Hr. Ft.	Gal. Water Required Per Hr.	V Feet Per Sec.	Length of Pipe ½ Mi.	1 Mi.	1½ Mi.	2 Mi.	2½ Mi.	3 Mi.
			2-inch Pipe					
......	2000	3.188	79	158	237	316	395	474
......	2400	3.825	111	222	333	444	556	667
......	2800	4.463	148	296	445	593	741	889
......	3200	5.100	190	381	571	761	952	1142
......	3600	5.738	237	474	711	948	1186	1423
50	4000	6.37	288	577	866	1155	1444	1732
60	4800	7.65	406	812	1218	1624	2030	2436
70	5600	8.92	542	1083	1625	2167	2708	3250
80	6400	10.20	695	1391	2086	2781	3477	4172
90	7200	11.47	867	1733	2600	3466	4333	5200
100	8000	12.75	1055	2111	3166	4221	5277	6332
			2½-inch Pipe					
......	2000	2.233	33	65	98	130	163	195
......	2400	2.679	46	91	137	183	229	274
......	2800	3.126	61	122	183	244	305	366
......	3200	3.572	78	157	235	313	392	470
......	3600	4.019	98	195	293	390	488	586
50	4000	4.47	119	238	357	476	595	714
60	4800	5.36	167	335	502	669	836	1004
70	5600	6.25	223	446	669	893	1116	1339
80	6400	7.15	286	573	859	1146	1432	1719
90	7200	8.04	357	714	1071	1428	1785	2142
100	8000	8.93	435	870	1304	1739	2174	2609
			3-inch Pipe					
......	2000	1.448	11	22	33	44	55	66
......	2400	1.737	16	31	47	62	78	93
......	2800	2.027	21	41	62	83	104	124
......	3200	2.316	27	53	80	106	133	159
......	3600	2.606	33	66	99	132	166	199
50	4000	2.89	40	80	121	161	201	241
60	4800	3.47	57	113	170	226	283	339
70	5600	4.05	75	151	226	302	377	453
80	6400	4.63	97	194	291	388	485	581
90	7200	5.21	121	242	362	483	604	725
100	8000	5.79	147	294	441	588	736	882

Head Ft.	Pressure Per Sq. In.	Head Ft.	Pressure Per Sq. In.	Pressure Per Sq. In.	Head Ft.	Pressure Per Sq. In.	Head Ft.
10	4	200	87	4	9.2	50	115
20	9	300	130	5	11.5	60	138
30	13	400	174	6	13.8	70	161
40	17	500	217	7	16.1	80	184
50	22	600	260	8	18.4	90	207
60	26	700	304	9	20.7	100	230
70	30	800	347	10	23	200	461
80	35	900	391	20	46	300	691
90	39	1000	434	30	69	400	922
100	43	2000	868	40	92	500	1152

A 2-in. pipe=2.067 internal diam. The formula used is the Hazen-Williams Formula.
A 2½-in. pipe=2.469 internal diam.
A 3 -in. pipe=3.068 internal diam.

$H=K\frac{d^{1.25}}{lv^{1.87}}$ in which

H=loss of head due to friction.
K=.00038.
i=length of pipe in feet.
V=velocity of water in feet per second.
d=diameter of pipe in feet.

Waterways and Gutters

Standards of Pennsylvania State Highway Department

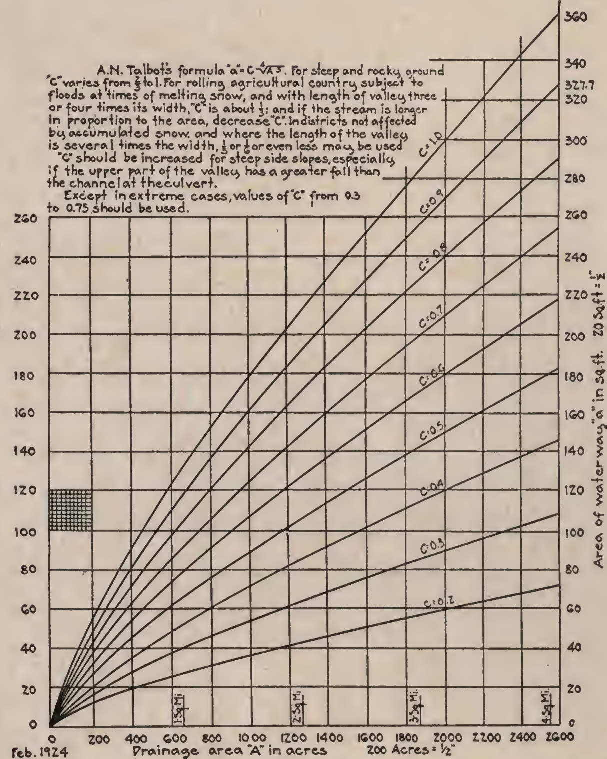
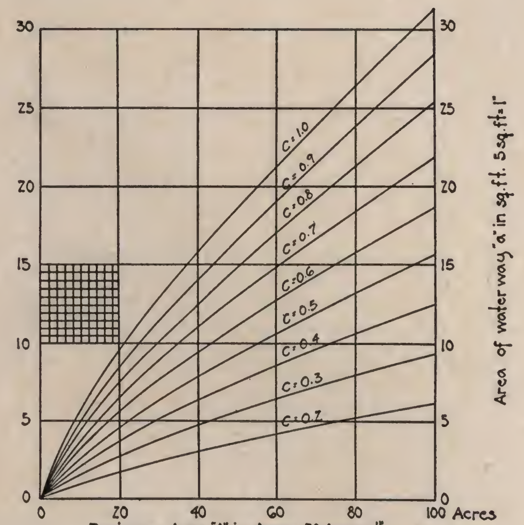


Diagram for Determining Waterways for Bridges and Culverts.



A.N. Talbot's formula, $a = c\sqrt[4]{A^3}$. For steep and rocky ground "C" varies from 2/3 to 1. For rolling agricultural country subject to floods at times of melting snow, and with the length of the valley three or four times its width, "C" is about 1/3; and if the stream is longer in proportion to the area, decrease "C". In districts not affected by accumulated snow and where the length of the valley is several times the width 1/5 or 1/6 or even less may be used. "C" should be increased for steep side slopes, especially if the upper part of the valley has a greater fall than the channel at the culvert.

Excepting in extreme cases, values of "C" from 0.3 to 0.75 should be used.

Note:- To find values of "a" for values of "C" between these curves, use value of "a" on curve "C" = 1.0, and multiply it by any value of "C" you desire to use.

Diagram for Determining Waterways for Bridges and Culverts.

Material required for one (1) cubic yard of concrete.
Assumptions:- 1 barrel Cement = 4 cu. ft. – Sand voids = 42% – Stone voids = 45%

MIXTURE	CEMENT BBLS.	SAND CU. YDS.	STONE CU. YDS.	MIXTURE	CEMENT BBLS.	SAND CU. YDS.	STONE CU. YDS.
1 : 1½ : 3	1.9176	.4262	.8523	1 : 3 : 5	1.2294	.5464	.9107
1 : 2 : 3	1.7719	.5250	.7875	1 : 3 : 6	1.1175	.4967	.9934
1 : 2 . 4	1.5481	.4587	.9174	Class "A" (1 : 2 : 4)	1.5481	.4587	.9174
1 : 2½ : 4	1.451	.537	.884	Class "B" (1 : 2½ : 5)	1.2981	.4808	.9616
1 : 2½ : 5	1.2981	.4808	.9616	Class "C" (1 : 3 : 6)	1.1175	.4967	.9934

1:1½.3 MIXTURE.

Concrete watering trough
Concrete piles

1:2:3 MIXTURE.

Cement concrete header curbing.
One course plain cement concrete pavement.
One course reinforced cement concrete pavem't.
Plain cement concrete gutter
Combination cement concrete curbing & gutter.
Monuments.
Replacing concrete header curbing.

1:2:4 MIXTURE.

Plain cement concrete curbing.
Armored cement concrete curbing.

1:2½:4 MIXTURE.

Plain cement concrete base course (slag aggregate)

1·2½:5 MIXTURE.

Plain cement concrete base course (stone or gravel aggregate)

CLASS "A" (1:2·4 MIX)

Concrete copings.
Concrete base for monuments.
Concrete cribbing.
Concrete floor & parapet of bridge & culvert.

CLASS "B" (1:2½:5 MIX.)

Cement concrete inlets (types A-B-C-D-E-F.)
Cement concrete headwalls (types A-B-C-D-E-F.)
Retaining wall (exclusive of foundation.)
Concrete headwall at outlet to underdrain.
Manhole floor.
Concrete base for watering trough.
Concrete foundation for bridge or culvert.
Concrete abutment for bridge or culvert.

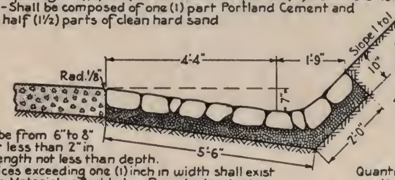
CLASS "C" (1:3:6 MIX.)

Retaining wall foundation
Small standard arch foundation.

Cement Concrete Mixtures for Standard Structures and Pavements.

Dry Filler - Shall consist of clean gravel, coarse sand or stone screenings of such size that when dry, will pass thru a laboratory screen with circular openings not more than five eighth (5/8) inch, nor less than one quarter (1/4) inch in diameter

Grout Filler - Shall be composed of one (1) part Portland Cement and one and one half (1½) parts of clean hard sand



6" Concrete Header Curb at ends where deemed necessary

45% voids allowed
088 cu. yds Stone,
092 " " Rock, slag screenings or gravel bed

Stones to be from 6" to 8" in depth, not less than 2" in width and length not less than depth.

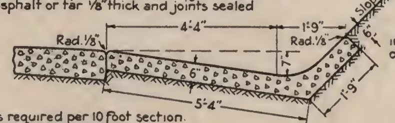
No interstices exceeding one (1) inch in width shall exist

Foundation Material or bed to be of crushed rock, slag screenings, or gravel, passing thru five eighths (5/8) inch circular openings; approximately 4" deep.

Quantities req'd per lin. ft (Solid Content)
:61 cu. yds. Stone,
052 " " Rock, slag screenings or gravel bed

PLAIN AND GROUTED RUBBLE GUTTER.

Between butting ends of sections of gutter and between gutter and pavement - paint construction joint with approved asphalt or tar 1/8" thick and joints sealed

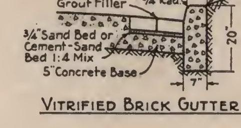


To be constructed in alternate sections of ten (10) feet 1.2·3 Concrete

Quantities required per 10 foot section.
1.31 cu. yd. 1:2·3 Concrete

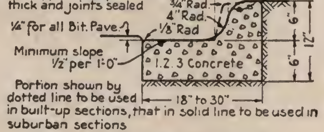
PLAIN CEMENT CONCRETE GUTTER.

3" or 4" Bricks to be placed parallel or at right angles to the axis of the roadway



VITRIFIED BRICK GUTTER.

Between butting ends of sections of gutter and between gutter and pavement - paint construction joint with approved asphalt or tar 1/8" thick and joints sealed



Portion shown by dotted line to be used in built-up sections, that in solid line to be used in suburban sections

COMBINATION CEMENT CONCRETE CURBING AND GUTTER.

Standard Gutters.

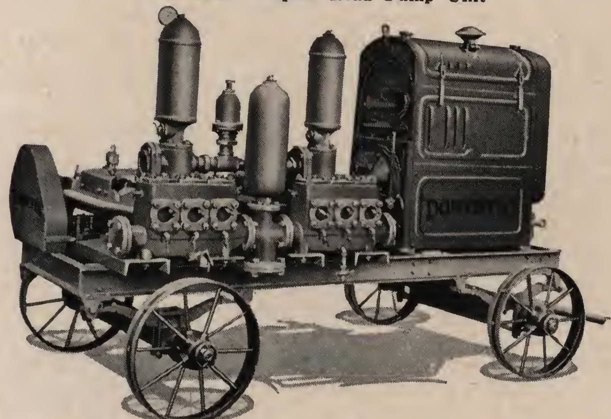
DOMESTIC ENGINE & PUMP CO.

Shippensburg, Pa.

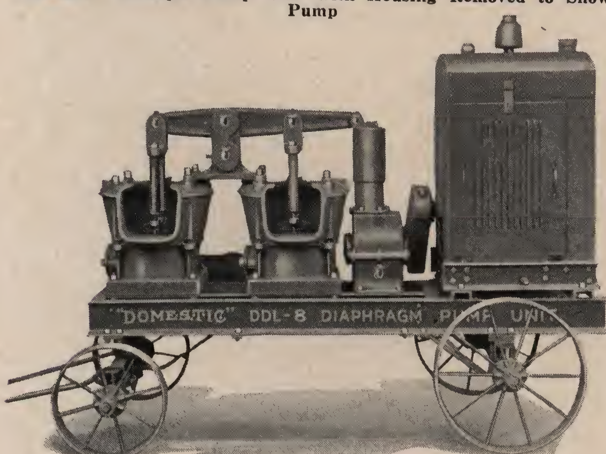
Manufacturers of Contractors' Pumps and Hoists

Products: Road Builders' Force Pumps, Plunger Force Dewatering Pumps, Diaphragm Pumps, Jetting Pumps, Centrifugal Pumps and Hoists.

"Domestic" Triplex Road Pump Unit



"Domestic" Sextuple Pump Unit with Housing Removed to Show Pump



"DDL-8" Diaphragm Pump Unit

"Domestic" Giant Road Pumps: "Giant" Road Pump Units are assembled with 20 and 35 H. P., 4 Cylinder industrial type engines, and for pumping capacities of 60, 80, 100 and 150 gallons per minute against back pressures up to 500 pounds. **Pressure oiling system.** Oil supplied under pressure direct to every bearing. **Extra heavy crank shaft,** thus removing all dangers of distortion or breakage under maximum loads. Crank shaft is drilled for oil passage to all its bearing surfaces. Dirt proof and oil retaining pump and gear housings. **Hyatt roller bearings** on pump drive shaft, and pinion gear shaft. Regular mounting is **steel wheel trailer with springs.**

Giant Road Pumps recommended for use with 27-E Paver.

"Standard" Triplex Pump Units have 15 H. P., 4 Cylinder engines and are built for 60, 80 and 150 gallons per minute capacity against back pressures of 300 225 and 100 pounds, respectively.

"Domestic" Sextuple Jetting Pumps: "Domestic" Sextuple Jetting pumps have six cylinder, outside packed, single acting plunger pumps driven direct from 35 H. P., 4 Cylinder engine and mounted on spring type, steel wheel trailer trucks. This construction gives positive pressure, not effected by grit in water, and minimum expense in upkeep. Sextuple Pump Units are built in two types (automatic oiling and mechanically oiled pumps) with capacities of 300 gallons and 200 gallons per minute respectively. Designed expressly for jetting work, such as concrete piling and earth jetting for "forcing settlement of fill" on highway and railroad construction.

"Domestic" Diaphragm Pumps: The new improved "Domestic" diaphragm pumps have the power transmission gears and all bearings enclosed in dust proof and oil retaining housings. Absolute automatic lubrication combined with Hyatt Roller bearings insures long life with minimum attention. These units are dewatering pumps of large capacity (8,000 to 24,000 gallons per hour) and have the very maximum suction lift. They will give 24 hours a day service with the minimum of care and their upkeep is very small. "Domestic" Diaphragm Pump Units are recommended for use on bridge foundations, cofferdams or other places where dewatering is required.

Catalogs and prices covering any of the above units or the "Domestic" line of Centrifugal Pumps, Force Dewatering Pumps and Hoists sent on request.

Industrial Railway Haulage

Gasoline Locomotives.—The three sizes of gasoline locomotives that are commonly used in road work are 3, 6 and 7-ton.

The draw bar pull is often estimated to be equal to the weight of the locomotive divided by its speed in miles per hour. Thus, a 6-ton locomotive weighs 12,000 lbs., and at 10 miles per hour its draw bar pull is 1,200 lbs., whereas at 5 miles per hour it is 2,400 lbs.

One manufacturer gives the following for its 7-ton (14,000 lbs.) locomotive:

	Miles per hr.	Draw bar pull, lbs.
Low gear	3	5,250
Intermediate	4.5	3,520
High gear	10	1,550

Another manufacturer gives the following for its 7-ton locomotive where the rails are "well sanded":

	Miles per hr.	Draw bar pull, lbs.
Low gear	2	4,200
Second gear	4⅛	3,500
Third gear	7¼	2,500
High gear	10⅛	1,725

This 7-ton locomotive is 4-cylinder, 4½-in. bore by 6¼ in. stroke, 60 h. p. at 1,400 rev. per min.

Gasoline engines ordinarily consume about 1 pint of gasoline per horsepower hour when running continuously, at which rate a 60 h. p. engine would consume 75 gals. in 10 hrs.; but, as a matter of fact, only about 15 gals. are consumed per day when the distance traveled is 30 miles a day. To this add ½-gal. of engine oil and 1 gal. of transmission case oil.

The life of the heavy steam locomotives is about 20 years, but a contractor should not estimate a life of more than 10 years for small locomotives, for they may be superseded by better designs long before they are worn out. The repairs of heavy steam locomotives annually average 24 per cent of their first cost, but this is for continuous service. A contractor should estimate repairs at fully 2 per cent per month worked. Hence with, say 5 working months per season, the repairs will be 10 per cent; to which add, say, 10 per cent for depreciation and 6½ per cent for interest. Divide the total by 100 to get the plant rental charge per day actually worked. For a locomotive costing $4,000, this gives $10 per day worked as the plant rental cost.

Hauling with Dinkeys.—The ordinary "contractor's steam locomotive," or "dinkey," travels on a track of 3-ft. gage. The size of dinkey commonly used weighs 8 short tons, and is listed as having a tractive pull of 2,900 lbs. on a level track. The loads that a dinkey can pull are usually much over-estimated in catalogs, due to too low rolling resistance assumed for cars.

It is said in some of the catalogs that the resistance to traction is 6½ lbs. per short ton. This rate applies only to the best of standard railway tracks with heavy rails, well ballasted, and with heavy wheel loads. On a contractor's narrow gage, light rail track, the resistance to traction probably averages not much less than 40 lbs. per ton, and at the place where the cars are loaded it is doubtless more, due to the dirt on the rails.

The resistance due to gravity is 20 lb. per short ton per 1 per cent of grade; but, of course, the tractive power of a locomotive falls 20 lb. for every ton of its own weight for each 1 per cent of grade.

Based upon these data, and upon the assumption that the resistance to traction is 40 lb. per short ton, an 8-ton dinkey is capable of hauling the following loads, including the weight of the cars:

	Total tons
Level track	70
1% grade	46
2% "	33
3% "	26
4% "	21
5% "	17
6% "	14
8% "	10

Note: On a poor track not even as great loads as the above can be hauled.

Due to the accidents that frequently occur from the breaking in two of trains on steep grades, and from the running away of engines, it is advisable to avoid using grades of more than 6 per cent.

When heavily loaded, a dinkey travels 5 miles per hour on a straight track; but when lightly loaded, or on a down grade, it may run 9 miles an hour.

The following are the average struck measure capacities of the dump cars made by one firm (variations of weight of several hundred pounds occur, according to the make):

Capacity, cu. yd.	1	1½	2	2½	3
Weight, lb.	1,700	2,000	2,300	2,800	3,500

A car seldom averages its struck capacity of earth measured "in place," even when the car is heaped full with a shovel; for not only are there vacant places in the corners of the car, but the loose earth is 20 per cent to 30 per cent more bulky than earth "in place."

The 3-ft. gage track commonly used for hauling earth is laid with rails weighing 15 to 40 lb. per yard of single rail. A 30 or 35-lb. rail makes a track that is not easily kinked under the loads, even when ties are spaced 4 ft. centers. A 6x6-in. tie, 5 ft. long, is the best size. I have tried 4x4-in. ties, but they are easily split by the spikes, and are not of much value after being used once; whereas the 6x6-in. ties can be laid 5 to 6 times. After the rails and ties are delivered, and the roadway graded, such a track can be laid for $300 per mile when wages are 50 ct. per hour. And the track can be torn up and loaded on wagons for $150, there being 1 ton of 30-lb. rails, and 375 ft. B. M. of 6x6-in.x5-ft. ties per 100 ft. of track.

Resistance of Rolling Friction.—With extra good cars and track rolling friction may be as low as 5 lb. per ton of 2,000 lbs.; but 6⅛ lb. may be taken for first-class cars and track, 8 to 12 lb. for reasonably good conditions, and as high as 20 to 40 lb. for bad cars and track, and 60 to 80 lb., or even more, for excessive hard-running cars and very rough track. Cars with wheels fast on axles and suitable bearings and oil boxes should not exceed 8 to 12 lb.; logging cars may run 6½ to 12 lb. if of good construction, up to 20 or even 40 lb. if with poor arrangement for oiling. Contractors' dump cars are usually hard-running, say 10 to 25 lb.; coal-mine wagons, with loose wheels, are seldom less than 15 lb., and often exceed 30 lb. and with the holes in the wheels worn out of true, and the wheels scraping against the sides of the car, may develop 60 to 80 lb., or even greater resistance. Street cars may be reckoned at 15 to 25 lb. The resistance of flange friction on wooden rails is an indeterminate quantity, but usually twice the resistance on steel rails. Poorly laid track and crooked rails increase the resistance indefinitely. Overloading cars also increases the resistance greatly.

The resistance is greater in cold weather. The resistance of rolling friction per ton is greater for empty cars than for loaded cars.

PERCENTAGE TABLE FOR APPROXIMATE COMPUTATION OF HAULING CAPACITY

Grades	Percentages figured to include frictional resistance per ton of 2,000 lb.					
On absolute level the pc.	6½ lb.	10 lb.	15 lb.	20 lb.	30 lb.	40 lb.
of hauling capacity is	100	65.	43.3	32.5	21.6	16.2
1% Grade	23	20.4	17	14.5	11.5	9.3
2% "	12.5	11.5	10.3	9.3	7.7	6.6
3% "	8.3	7.7	7.1	6.6	5.6	4.9
4% "	6.0	5.6	5.3	4.9	4.3	3.8
5% "	4.5	4.3	4.0	3.8	3.4	3.0
6% "	3.6	3.4	3.2	3.0	2.8	2.5
7% "	2.9	2.8	2.6	2.5	2.2	2.0
8% "	2.3	2.2	2.1	2.0	1.8	1.6
9% "	1.9	1.8	1.7	1.6	1.5	1.4
10% "	1.5	1.5	1.4	1.4	1.2	1.1
11% "	1.3	1.2	1.2	1.1	1.0	.9

To obtain the hauling capacity on any grade for track of any frictional resistance, multiply the hauling capacity of the locomotive on a level for a rolling friction of 6½ lb. per ton, by the factor given above and point off two decimal places. The actual resistance of rolling friction may be determined by noting on what down grade a car once started will just keep in motion. If a car will hardly keep in motion if started down a 1 per cent grade, its frictional resistance is just about equal to 20 lb. per ton; the same proportion will hold for other grades.

Water and Fuel Consumption of Dinkey Locomotives.—The number of gallons required per mile by a locomotive is approximately 1 per cent of the total resistance to be overcome. The total resistance is expressed in lb. and is equal to 20 times the percentage of grade plus the rolling friction in lb. per ton, times the total weight of the train, engine, tender, cars and load expressed in tons of 2,000 lb.

The number of lb. of coal required per mile under the most favorable conditions is very nearly the same as the number of gallons of water. Under unfavorable conditions as much as 40 per cent more coal may be required. This relation of coal to water required is based on the assumption that 1 lb. of coal will evaporate from 5 to 8 lb. of water.

Cost of Laying Light Railway.—Dana in his *Handbook of Construction Plant* gives the following:

Contractors' light track of 30-lb. rail with 36-in. gauge was laid on a grading job. Teams and drivers cost 90 ct.; labor, 40 ct., and foreman, 60 ct. per hour. The rail and ties, which latter were of 6x6-in. spruce, 5 ft. long, were gathered from various places on the work and hauled by horses an average distance of 1,500 ft. to the site of the track; 1,000 ft. of track, including 2 complete switches, with ties 4 ft. apart, were laid, at a total labor cost of $105, or $575 per mile.

1,500 lin. ft. of track, including two switches, similar to above, were laid on another job in five days at the following cost:

1 foreman at $6.00	$ 30.00
8 men at 4.00	160.00
1 man at 5.00	25.00
1 man at 4.50	22.50
1 team at 9.00	45.00
Total (1,500 ft. at 18.84 ct.)	$282.50

Portable Railways in Road Construction

Cost of Hauling on New York Road Job.—*Engineering and Contracting* gave the following:

The equipment used on roadwork near Lockport, N. Y., consisted of about four miles of narrow-gauge portable track, 40 (36x24-in.) dump cars and two 5-ton dinkey locomotives. The cars were hauled in trains of 12 cars each, the arrangement being so made that there was always one train of loaded cars on the way to the site of the work, one train of empties returning for material and one train of cars being loaded. The average amount transported was 80 cu. yd. per day.

While hauling stone three miles from a crusher at the quarry to the road the cost of operating the trains was as follows:

Fuel and oil for locomotives and cars	*$16.00*
Labor:	
2 enginemen at $6.00	12.00
2 brakemen at $4.00	8.00
1 track foreman at $5.00	5.00
1 track laborer at $4.00	4.00
Totals	$45.00
Cost per cu. yd.	$0.5625

As the material was hauled three miles the labor and fuel cost was 18.8 ct. per cu. yd. per mile. The average cost of grading the shoulder or berm of the road ready for track laying and laying track was between 4 and 6 ct. per foot of track.

Cost of Industrial Railway Haulage on Texas Road Job.—The following data was given in *Roads and Streets* on industrial railway haulage in concrete road construction and was taken from the Bulletin of the Associated Pennsylvania Highway Contractors. The haulage was for the Iowa Park-Electric concrete road in Wichita County, Texas. Potts & Prentice were the contractors:

Width of pavement, ft.		18
Average thickness, in.		8
Total pavement placed in April, 1921	Reinforced with wire mesh	Not reinforced
	26,076 sq. yd. 13,038 lin. ft.	12,600 sq. yd. 6,300 lin. ft.
	Total pavement	38,676 sq. yd. 19,338 lin. ft.
Working days		21½
Maximum lin. ft. days run (both mixers)		1,033

Tonnage handled per train:	Gross.	Tare.	Net (Con. matl.).
Cars—10 at 1,000 lb.	....	10,000	....
Batch boxes—20 at 450 lb.	....	9,000	....
Stone—270 ft. at 105 lb.	....	....	28,360
Sand—160 ft. at 110 lb.	....	....	17,600
Cement—70 sack at 96 lb.	....	....	6,720
	71,680 lb. 35.84 ton	19,000 lb. 9.5 ton	52,680 lb. 26.34 ton

Average haul (miles)	2
Grades against loaded trains, east mixer	None
Grades against loaded train, west mixer	0.8% (max.)
Average number of trains per day	31
Maximum number of trains per day	36
Number of trains operated per day	5
Average net tonnage concrete material hauled per day	816.5
Average gross tonnage handled per day	1,111.0
Maximum net tonnage handled per day	948.24
Maximum gross tonnage handled per day	1,290.24
Average net ton miles per day	1,633

Cost of operation, average day:				
5 locomotive drivers, at	$7.50	$37.50		
3 hours master mechanic	1.25	3.75		
75 gal. gas, at	.18	13.50		
2½ gal. oil, at	.70	2.10	(1.75)	$56.85
Track gang, maintenance, moving track and switches from east to west mixer:				
4 to 5 men, at	.40	20.00		
1 foreman	7.50	7.50		27.50
Total operating cost				$84.35

Hauling Macadam Over a Portable Track in Illinois. —According to Fred Tarrant, in *Engineering News*, two 20-h.p. locomotives, 6 miles of portable track and 1.5-yd. steel dump cars were used in the construction of a 12.5 water-bound macadam road, 10-ft. wide, in Illinois. Rails and ties were made in 15-ft. sections, weighing 225 lb. Two flat cars were used for hauling the track, but trains of dump cars coupled together with 6-ft. poles were better.

A track crew of four men could lay an average of 2,000 ft. of track per day. In order to keep the track in good alignment, one man was required continuously to watch and correct low joints and loose connections.

By placing 10 to 12 cars ahead of the locomotive, and from 12 to 16 cars behind it—depending upon the grade—one locomotive could handle long trains. Where the grade was 4 per cent or over, the engine dropped to the rear end of the train, and pushed the forward cars to the top of the hill, returning for the other half of the train later. Switching in the yard was handled by a mule. The equipment on one job was rented for 6 months, and, in five months, 35,473 cu. yd. of broken stone were handled, with an average haul of 3.17 miles, at a cost on the rental basis, including all the expenses and hauling both ways, of 14.8 ct. per ton-mile. This included also the necessary expenses for the equipment in first class shape. Team hauling on this job was estimated to cost at least 28 to 30 ct. a ton-mile.

Hauling Macadam Over a Portable Track in Michigan. —R. P. Mason, in *Engineering and Contracting*, gave the following:

We had a very considerable stretch of macadam road to build, and, in anticipation of a continuous program covering several years, an outfit was purchased consisting of a 30 h.p. locomotive, 50 cars, a track-laying car and four miles of 24-in. gage portable track with curves and switches. This track is 20-lb. rail, made up in 15-ft. sections with seven steel ties to the section. This unit is readily handled by two men. It is necessary to have track that is really portable and for this reason this type was selected.

Our season's work was 9.5 miles of 16-ft. macadam 6 in. in depth compacted, laid in two courses, on what is known as the Manistique Trunk, or the road connecting Escanaba with Manistique.

We contracted for a sufficient supply of stone to keep the outfit busy to maximum capacity, to be delivered in hopper bottom cars; and I would say that this is a matter not to be overlooked, there must be a sufficient and constant supply of stone, and, if shipped to the job, the railroad equipment must be in proportion and of proper and uniform type of cars to facilitate rapid unloading, or the efficiency of the work will suffer. The total output of a good-sized quarry is required to keep this outfit busy, and, as we have handled over 400 cu. yd. (loose measure) per day on short and medium haul, it is evident that no small crushing plant or undeveloped quarry would keep things going.

A loader consisted of a 24-ft. elevator carrying 16-in. steel buckets, driven by a 6-h.p. gas engine, carries the stone from a pit beneath the standard track into two small bins—one for the large stone and one for screenings—the stone being deflected into the proper bin by a hinged door. A powerful winch, with steel cable, driven by the same engine, is used to spot the cars, both standard and small. The pit mentioned is fitted with a sliding door to control the flow of stone to the belt. The capacity of this loader is about 600 cu. yd. per day.

The portable track is laid under the bins with a siding to take care of the empty train. Suitable doors in the bins furnish the means of filling the train and the average time of filling a 25-car train is ½ hr. A train was supposed to be always loaded and ready.

Tracklaying is handled generally by three to four men and a car of steel is sent out as needed at the head end of the stone train, carrying 20 sections, or 300 ft. of track. As our day's macadam work seldom exceeded one-eighth of a mile, two to three cars of steel per day were sufficient. The track is laid on the shoulder after the grade is complete and made as permanent as possible, for it is found that it pays to have the track well leveled and solid in order to make time with the train. At least one man was kept going over the track constantly, especially in wet weather, to keep it in shape. As fast as any considerable section of the road was finished the track was thrown to the center of the road, the metal thus giving a perfect roadbed for the long haul.

The speed of the train was about 10 miles per hr., though that was not maintained as an average on account of a number of railway grade crossings, where a watchman was stationed and where a short section of track had to be placed and removed for the passage of every train.

Trains of 20 cars were hauled on the start and five cars were added later, making 25-car trains, and it is the intention to haul 30-car trains this season, as we find that the locomotive will easily handle that many on our ordinary grades. Cars were loaded with 1¼ cu. yd., which, when dumped at a standstill, just made one course of the large stone. The loaded train is always pushed in order to have the locomotive back of the dumped stone. The haul was about 3½ miles each way from the set-up; season's average nearly eight trains per day and 236 cu. yd. per day of stone.

The spreading was done with a road machine hauled by two teams. When the cars were dumped there was always some stone left in them, but as the machine cut close to the cars, after the second trip the remainder was removed with a rake in a moment and the train was free to pull out. The unloading did not consume to exceed 10 min.

The road machine finished the spreading while the train was making another trip and a very little trimming with rakes left the road in perfect condition for rolling.

The crew required was about as follows:

Loader	4 men
Train	2 men, engineman and brakeman
Spreading	2 teams and teamsters
Spreading	5 to 7 men
Rolling	3 men
Sprinkling	2 teams and teamsters
Foreman	1
Watchmen	1 or more
Tracklaying	4

Wages were $4 per 10-hr. day for laborers, $8 for teams with teamsters, $6 for rollermen and enginemen, $180 per month.

Compared with team haul the method described shows a saving of about 30 ct. per cu. yd., or nearly $700 per mile. We also save 39 ct. on our stone and 10 ct. on the unloading, making a total of about $1,800 per mile over previous prices. The saving on haul alone would be more marked on a longer haul. We also used the outfit in grading where material had to be moved some distance and found it extremely convenient and economical. Another very decided advantage of road build-

ing by this method is seen in the fact that there is no hauling over the road during construction and it is opened to traffic in perfect condition. It is also easier to keep the subgrade from being cut up and therefore, takes less stone for a given thickness.

The following costs include everything that is a proper charge to the work, the cost of moving outfit from one point to another, laying up, and tracklaying includes taking up as well. Loading includes setting up loader and in one case building a siding 1,000 ft. long. The number of watchmen makes the hauling cost high; a greater output will cut down the spreading and the overhead in this case is high on account of the short season.

Number of days worked	93
Miles of finished stone	9.44
Number yards stone used	21,920
Number yards stone used per mile	2,310
Number days to build mile of road—average	9.4
Number yards of stone per day	236
Cost of tracklaying per mile of finished road	$216.20

	Cost per cu. yd.
Cost of stone at our siding	$2.600
Loading trains	.104
Tracklaying	.094
Engineman	.040
Brakeman	.026
Watchmen	.034
Coal	.024
Oil, grease and waste	.004
Repairs	.006
Total per cu. yd. loose	$2.932
Interest and depreciation on $30,000 hauling outfit	$0.097
Spreading	.228
Sprinkling	.086
Rolling	.164
Foreman and timekeeper	.060
Total	$0.635
Interest and depreciation on all other machinery	$0.080
General expense	.062
Total	$0.142
Total cost per yd. (loose) of finished road	$3.709
Cost per mile	$8,567.79

In *Engineering and Contracting*, Mr. Mason gave the following additional information:

The conditions necessary for the successful operation of an industrial railway in highway construction are as follows:

First, fairly level country. We haul 30-car trains over grades up to 3 per cent and have worked over a 1,000-ft. hill of 5.1 per cent by cutting the train in three parts at the foot; in other cases we have used a roller to tow up, but many such hills make it out of the question. If the hills were not too frequent other power could be provided.

Second, sufficient and continuous supply of material. As such an outfit will handle a large volume (at 8 trips per day 300 yd.) and as it requires a considerable crew to keep the work moving, it will not pay if there is much delay in the delivery of road material, or if the loading facilities are inadequate. I am considering the question of stock piling some material in order to keep going when deliveries are delayed, but this presents the further problem of loading from the stock pile. Our loader could not be utilized and another rig would have to be provided.

Third, a considerable mileage to be constructed from one set-up to avoid the expense of numerous moves. We figure on at least 8 miles at one set-up, 4 miles each way. If the road is continuous and the move is only from the end of a completed section to a point 4 miles beyond, the moving cost will be a minimum, but if the outfit has to be moved to a distance, the cost is heavy. Our maximum haul so far has been 4 miles, as we have been fortunate in having our work along the railroad with frequent stations. Our outfit consists of a 30-h.p. locomotive with underslung tank, 60 1½-yd. side dump steel cars, 1 tracklaying car, 1 hand car and 4 miles of 24-in. gage portable track with curves and switches. The track is 30-ft. rail made up in 15-ft. sections with 7 steel ties to the section.

The outfit cost about $30,000. We depreciate 10 per cent on all the machinery, but only 5 per cent on the track, as at the end of 10 years the salvage value will be at least half the first cost. It is also evident that there will be considerable value in the rest of the outfit at the end of the 10-year period. It is now 5 years old and practically as good as new.

Tracklaying is one of the large items in operating and this will vary considerably according to the character of the soil. In swamp sections, where the shoulders have not much stability, it is necessary to shim up frequently to keep the track in safe condition, but on a firm soil, such as sand or gravel, it does not need much attention after laying. Our cost has varied from $200 to $300 per mile, with an average of about $269.

When the outfit is also used for grading it cuts the tracklaying cost, as the track is then in position for the stone work. During a move and while the macadam work is on the short haul, some of the cars and track can be spared for grading without delaying the other work, using a team to haul the train. Especially in soft sections, it is very useful, and, in heavy cuts, working with a small shovel it shows great economy. The fact that the outfit has to be there anyway should be considered, as it involves no transportation to and from the job.

Hauling 30-car trains and loading one while the other is making a trip, should admit of an average of 10 trips per day on a haul up to 4 miles—2 miles average haul—and we have made this at times, but various delays, principally in the delivery of stone, have combined to cut the average down to 8 trips. I think the train should average 6 trips on a haul up to 8 miles, as the delays in unloading and at the loader would be less and it would only mean an average of 48 miles per day actual running. At this rate, hauling 47 tons per trip would equal 282 tons per day. Speed of train is 8 to 10 miles per hour and time of unloading 10 to 15 minutes. Time of loading is about ½ hour, but, of course, this does not delay the train. At times when our stone supply was sufficient we have averaged over 400 cu. yd. per day, or at the rate of a mile of road built in 6 days.

The following costs are an average of 3 years and cover about 20 miles of 16-ft. 6 in. macadam construction:

	Per cu. yd.
Tracklaying	$0.100
Engineman	.050
Brakeman	.026
Watchman	.020
Fuel	.020
Oil, grease and waste	.004
Repairs	.030
Moving	.050
Total operating	$0.300
Depreciation	.110
Interest	.070
Total hauling	$0.480
Cost per yard mile	$0.240
Cost per ton mile	$0.192

Delivering the stone on the road as above affords an opportunity of keeping the other construction costs

at a minimum. Loading with an elevator is about the cheapest method and spreading the stone with a road machine is cheaper than by hand and planes the road at the same time, avoiding minor inequalities which so often occur. Rollers and sprinklers are kept up to their full capacity.

The other costs of the macadam construction follow:

	Per cu. yd.
Loading	$0.140
Spreading	.320
Sprinkling	.130
Rolling	.420
Total	$1.010
Hauling as above	.490
Total per cu. yd. (loose) measure	$1.500

(There are about 1.6 cu. yds. loose measure per cu. yd. packed macadam.—Ed.)

General Data on Industrial Railway Haulage

In a paper presented at the annual convention of the American Road Builders' Association, Mr. A. J. Parish, contractor, of Paris, Ill., gave the following:

Influence of Topography.—Of course, the ideal job is a level one from end to end, and the more nearly we approach that ideal condition the better the industrial equipment will work. But industrial equipment, properly handled, will give a good account of itself even if the topography of the country is not all that we would desire. Many different conditions confront the contractor in rolling country and there are numerous methods of furnishing extra power. In 1920 we had 800 ft. of 6½ per cent grade where we used a tractor to help the engines over. In 1921, on a grade 3,000 ft. long, averaging from 1½ to 3 per cent, we used a truck. On a short grade a good team is a good temporary expedient. Often extra engines can be spared to help out or the switches can be so arranged that the engine on the empty train can double over the hill with the load. The whole purpose of any haulage equipment is to feed the mixer and if switches are placed properly this end can be attained with industrial equipment as well as with any other method of hauling.

Size of the Job a Factor.—There is another feature which I think more important for successful operation of industrial equipment than the topography of the country, and that is the size of the job. Industrial railway haulage is best suited to large jobs with few set-ups. Where work is let in scattered sections it means increased overhead expense to use industrial haulage. Therefore, contractors using industrial equipment are handicapped in bidding on short sections.

The layout and equipment may change for any particular job, but there must be enough engines, cars, etc., on the job to keep the mixer going. On our work we have been using 3-ton gasoline locomotives. We expect to try out a 6-ton unit some time, but have favored the smaller engines for two reasons: First, it is easier to keep the track in condition, and, second, as a corollary to this, the track doesn't need to be so good, and it is easier to replace derailments.

Plant Arrangement and Operation Details.—Where we have plenty of room we set up our plant substantially as follows: The steam crane works along the side of the railroad switch storing the aggregates just as far from the track as it can reach. We build a small fence from 2 to 3 ft. high to hold the toe of the slope back from the crane and incidentally this fence saves wasting some material. We generally build a partition between the sand and coarse aggregate just heavy enough to separate them.

On the opposite side of the railroad from the crane are the bins with the industrial track running beneath them. The track is graded so that after the trains are pushed back they will roll by gravity through the bins and on to the cement house which is on the same side of the railroad switch as the bins. We have single track under the bins and a double track along the cement house.

We push our loaded trains to the mixer and pull the empty trains back. When an empty train returns to the yard it runs on the switch at the cement house. The engine is cut off and pushes the loaded train away from the cement house, then pushes the empty train back to the far bin before starting again to the mixer. This is the procedure when the mixer is working at the far end of its run, which, with our present equipment, would be 6 miles out if the job were of that length. After the mixer has reached a point 1¼ miles nearer the plant there will be an extra engine in the yard to push the empties back and do any other switching necessary.

We are using six 3-ton gasoline locomotives and they will keep our five-sack mixer going to capacity up to 6 miles from the plant handling 8 cars carrying 2 five-sack batches per car. On level grade they would handle 10 cars and would supply the mixer 7¼ miles from the plant. We never handle less than 8 cars away from the plant, even though we have to provide extra power over some grades or even split the trains, as we did one year in getting over 800 ft. of 6½ per cent grade. That grade was 3¾ miles from the plant and we were only using 4 engines. We put 2 engines to handling from the plant to the hill and 2 engines and a small caterpillar hauling over the hill to the mixer. We hauled for 1¼ miles of road over this hill. We were only using a four-sack batch that year, so we thought our average of 440 ft. per day was as good as could be expected.

Moves of Mixer Explained.—Our standard practice is to start the mixer at the plant and work away to within say 2 miles of the end. By that time our grade, track and pipe line will all be out. The mixer then goes to the far end and starts in. If we have the usual amount of bad weather the first concrete will be ready to travel over by the time the gap is closed. The mixer moves back to the plant and starts working away on the other side. We let our engines spot their own trains at the mixer. We have spotted by hand, teams and with the roller at times, when, for some reason, we were short of engines. The only time this ever happens is when, on the extreme haul, an engine is laid up for a few hours.

Because this sort of outfit and practice suits us doesn't necessarily mean that it is the best to be had or that it would suit you. Other contractors use bigger engines, both steam and gasoline, and get fine results. Some use bigger mixers and like them. One contractor built a big job in Illinois with only one steam engine, but it would handle about 50 cars each hauling a 9-sack batch. By having a switch along each shoulder, he could put his load in place without interfering with the unloading of the previous train.

When heavy engines are used it would seem to me advisable to spot cars at the mixer by hand or team rather than tie up your engines for the time necessary to unload a train, but no matter what method you decide on, good industrial equipment will do the work satisfactorily on jobs where conditions are suitable.

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Manufacturers of Steel Rails, Steel Ties, Track, Turnouts, Switches, Crossings, Steel Fence Posts, Steel Sign Posts, Etc.

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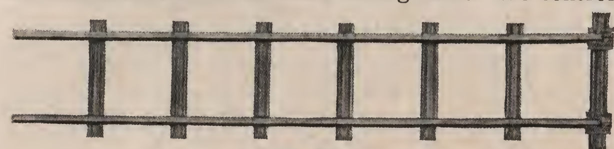
New York, N. Y.	**Pittsburgh, Pa.**	**Jacksonville, Fla.**	**Birmingham, Ala.**	**Seattle, Wash.**
Philadelphia, Pa.	**Cleveland, Ohio.**	**Montreal, Can.**	**Chicago, Ill.**	**San Francisco, Calif.**
Wilkes-Barre, Pa.	**Clarksburg, W. Va.**	**Mexico City, Mex.**	**Portland, Ore.**	**Los Angeles, Calif.**

Products: Light and Heavy Steel Tee Rails, Standard A. S. C. E. Sections. Also Special Sections. Steel Cross Ties or Sleepers, Splice Joints, Angle Joints with Complete Track Fastenings, Frogs, Switch-Points, Turnouts, Crossovers, Track-Climbers, Approaches, Ground-Throws, Straight and Curved Fabricated Track, Spikes, Track Bolts, Steel Fence, Steel Sign Posts, Etc.

Also Light Steel Angles, Channels, Flats, Concrete Reinforcing Bars, Plain Rounds, Squares, Twisted Squares, Etc.

Quality: Sweet's rails, steel ties and track accessories are manufactured in our own rolling mills. We control the quality and design. Nothing leaves our plant without rigid inspection and assurance of the user's complete satisfaction.



Steel Track

Ample stocks of the highest grade material enables us to make prompt deliveries no matter where you are located.

Features: There are many definite reasons why you should invest in Sweet's Steel Track, for instance:

Steel Ties

1.—The use of special steel in our steel cross ties; increasing strength and resiliency.

2.—The double corrugation that increases the rigidity of each tie and means greater efficiency and longer life.

3.—Method of attaching rails to ties. We can furnish either the clip and bolt design or the riveted track design.

4.—Sweet's Steel Track is made up in uniform 15-ft. sections; 5 meter sections for export (including switches, Etc), so that any section can be quickly replaced. Whole system is readily flexible to meet all conditions. The Sweet's system is complete in every detail.

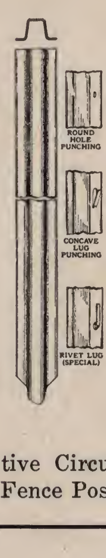
Sweet's Steel Track is known wherever experienced contractors and engineers run equipment on rails. It is making and saving money for its users.

Steel Ties: The strength of your track is the strength of the ties that bind the rails in position. The ties have to be strong, yet resilient under the loads of cars and other equipment.

That is why we use higher carbon steel cross ties in Sweet's Industrial Track. This is steel of a carbon content 2 or 3 times higher than in the ordinary steel tie. This is steel that resists distortion, or bending, to a greater degree than ever before.

Steel Fence and Sign Posts: Sweet's Steel Fence and Sign Posts are manufactured from Special High Carbon Steel and are the result of many years of study and development by our Designing and Engineering Departments.

Their advantages are unique, combining the superior strength of high carbon steel, maximum durability and resistance to weather and storm, pleasing appearance and an unequalled economy of maintenance.



Sweet's Fence and Sign Posts are sharp pointed for easy driving, are provided with or without ground anchor plate, and are easy to handle and easy to drive in any kind of soil. They eliminate the laborious digging of post holes, setting posts or tamping required with wooden posts, thus saving time and money.

All Sweet's Steel Posts are self-contained (one-piece), there being no accessories or parts to lose or replace. They are available in four sizes. Write for our Descriptive Circular describing this remarkable line of Steel Fence Posts.

THE FATE-ROOT-HEATH COMPANY

420 Riggs Avenue, Plymouth, Ohio

Manufacturers of Plymouth Gasoline and Diesel Locomotives

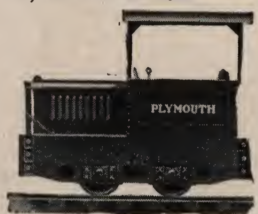
"If It's a Track Haulage Problem, There's a Plymouth to Solve It."

Products: A COMPLETE LINE OF GASOLINE AND DIESEL LOCOMOTIVE IN 2 TO 50 TON SIZES—A RANGE OF 26 STANDARD MODELS.

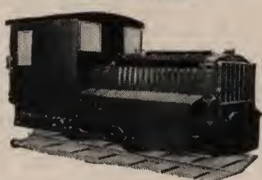
Plymouth Gasoline Locomotives: Sizes: 2, 2½, 3, 4, 4½, 5, 6, 7, 8, 10, 12, 14, 18, 20, 25, 30, 35 and 40 ton.

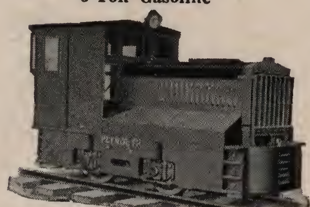
Plymouth Diesel Locomotives: Sizes: 10, 12, 15, 20, 25, 30, 40 and 50 ton.

15-Ton Diesel



2-Ton Gasoline


5-Ton Gasoline


8-Ton Gasoline

12-Ton Diesel

Advantages: Always ready to go, no coal, water or feed to haul, no "stand-by" expense. Thirty to fifty per cent cheaper to operate and maintain than steam. No licensed engineer required to operate. Larger sizes equipped with Automatic or Direct Air Brakes (Optional) as well as Hand Brakes.

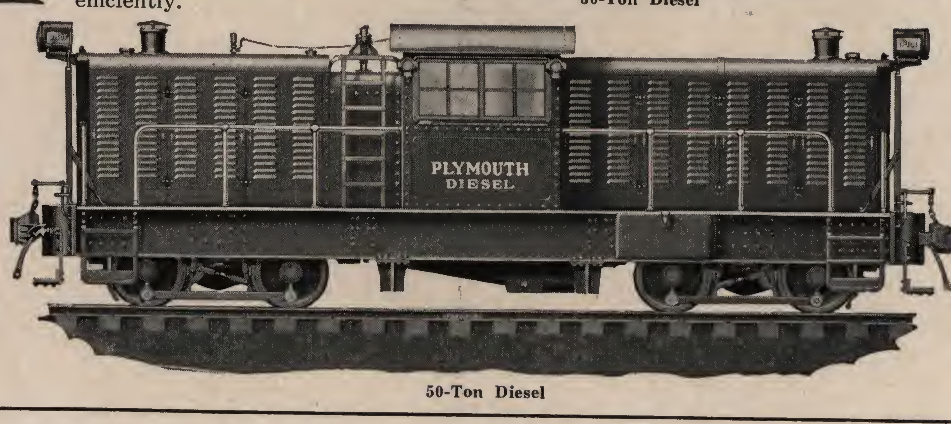
For Road Construction: In road construction profits are made by laying a big linear footage in the least time. Profits are lost by slow progress. The quantity of materials in a given mileage is fixed, whether poured in a month or a year. With an 8 ton Plymouth Gasoline Locomotive and portable track and cars, you can equal the haul of eight to twenty motor trucks, and without injury to grade or delays in wet weather.

For General Construction: For construction of dams, bridges, etc., for irrigation projects, for almost every excavating and construction job, where haulage is an important factor, there is in the Plymouth line a type and size designed to do that work most economically and efficiently.

25-Ton Gasoline

30-Ton Diesel

Recommendations and Literature: Without obligation we are prepared to give you unbiased and intelligent recommendation of the type of locomotive best adapted to your needs. Detailed descriptive Bulletins with lists of users gladly furnished on request.



50-Ton Diesel

Motor Truck Haulage

Although much is in print on this subject, it remains difficult to estimate trucking costs under different conditions accurately. Among the causes of this difficulty are:

1. Uncertainty as to the life of the truck. The life depends not only on the design of the truck but upon the operator and upon the care exercised in its maintenance. Overloading and "overdriving" (at excessive speeds), particularly on rough roads, greatly shorten the life. The life is estimated by different writers at 3 to 10 years, the prevailing practice being to allow 5 years. Sometimes the life is given in miles traveled, usually 80,000 to 100,000 miles. But as a mileage of 40 to 50 miles per day is commonly estimated, even if as many as 250 days were worked annually this would give 10,000 to 12,500 miles per year, or a life of 8 to 10 years. Probably this life is attainable over good pavements and with careful operation and maintenance, but on road construction where most of the haul is usually over rough roads, it is probably not safe to estimate a total life of more than 4 to 5 years, or a mileage life of 40,000 to 50,000 miles.

In road work the building season in the Northern states seldom exceeds 150 working days, of which usually not more than about 100 full days are actually worked. Obviously, motor trucks must be usually used for other purposes than road work, or the cost of motor truck haulage will be excessive.

2. Uncertainty as to repair costs. Repair costs depend so largely upon the character of the roads and the skill of the truck driver that it is difficult to estimate this item for any given condition. Repairs on any machine subjected to heavy usage increase with its age. Hence repair records relating to new machines are apt to be deceptive.

3. Percentage of lost time. This item has already been touched upon. It is particularly important in road work, for when the subgrade becomes soaked by rain, road work is usually suspended. Delays in arrival of materials by rail also add to the lost time.

4. Effect of variable length of haul. This, too, is a factor that is especially important in roadwork. The number of trucks busy on a road job at one time (when the haul is short) may be only three, but at another time (when the haul is long) it may be a dozen or more. Obviously there are periods when a given number of trucks will not quite suffice to handle the day's output of a concrete mixer, yet the addition of another truck will result in having one truck idle most of the time. Due to the constant change in length of haul, it is necessary to estimate at least one truck as being idle half the time.

5. Effect of variable load. The rated load for a truck is given in tons of 2,000 lbs., but the actual load may average more or less than the rated load. On road work a 1-ton truck usually carries 1.5 to 1.6 tons; and a 5-ton truck usually carries 6.4 to 6.8 tons. But on very poor roads, the load may be less than the rated capacity, whereas on well paved roadways the load carried by the 1 to 3-ton trucks may be double the rated capacity, and that carried by a 5-ton truck may be one and a half times the rated capacity.

As indicative of the cost of motor trucking, the following data will be discussed briefly. A questionnaire was sent to the Motor Truck Owners' Association of Philadelphia, and a summary of their costs for a 5-ton dump body truck was published in *Engineering and Contracting* as follows:

	Per Day Worked
Depreciation ($1,400 year)	$5.29
Repairs ($1,350 year)	5.11
Interest ($200 year)	0.76
Insurance ($330 year), fire, liability, etc.	1.25
License ($30 year)	0.11
Gasoline	3.42
Oil and grease	0.42
Tires	2.29
Driver	4.96
Garage	0.74
Overhead expense	1.74
Total	$26.09

The replies covered a total of more than 100 trucks. The average daily mileage was 40.5 miles, and the average number of days worked was 265, which would give about 10,700 miles a year.

At that time (1919) the price of a 5-ton truck and body was about $5,600, from which it appears that the average was estimated at 4 years, for the annual depreciation was given at $1,400. The annual interest, $200, is less than 4 per cent on the truck cost, from which it appears that some of the truck owners estimated the interest on the depreciated value. But if we estimate interest at 6 per cent on the cost new, we have:

	Annual Charge
Interest	6%
Depreciation	25%
Repairs	24%
Insurance	6%
Total	61%

The Associated General Contractors is authority for the following estimate (given in *Engineering and Contracting*) of annual expense on motor trucks:

	Per Cent of First Cost
Depreciation (3 yr. life)	33
Interest	5
Major, or shop, repairs	16
Minor, or field, repairs	16
Storage, incidentals and overhead	4
Insurance (fire)	1
Taxes	1
Total, 10 mos. use at 7.6%	76

The repair expenses seem high in both of the estimates just given, but even railway locomotives average annual repair expense about 18 per cent of first cost, an annual mileage of about 25,000 miles, and a life of about 25 years.

In hauling gravel over unpaved roads a 5-ton truck carried 6 tons to the load and used the following supplies:

Gasoline	3.5 miles per gal.
Motor oil	60 miles per gal.
Transmission oil	80 miles per gal.
Grease	80 miles per lb.

The following data relate to motor trucks operating in city streets:

Capacity of Truck	Miles Per Gallon Gasoline	Oil
1-Ton	12	125
2-Ton	6.5	75
3-Ton	5.7	60
5-Ton	4	40

The above relates to new trucks. As a truck grows older the consumption of gas and oil increases, often being 50 per cent more than when it is new.

The weight of a truck with a power-dump body is approximately the same as its rated capacity, thus, a 5-ton power-dump truck with body weighs about 10,500 lbs., and a similar 2-ton truck weighs 3,900 lbs.

In *Motor Transport* E. B. Neil says that "While in some instances trucks operating in the general haulage field may bring in amounts per day in the neighborhood of nearly $30.00, it is seldom that the owner receives more than about $25.00 or even less for a 5-ton unit with any regular contract arrangement in force between the truck operator and user. Investigation shows that many trucks of this size may be procured at $22.00 per day. For trucks used as dumpers in excavation or similar work, the fee may exceed $30.00, but such instances are rare if the truck is hired on a contract." He says that these rental rates are not adequate to yield a profit on an investment of $5,500, when the average distance traveled is 40 miles a day which is "shown correct for operation in congested localities."

If $25 a day yields no profit on a $5,500 truck, and if it averages 40 miles a day going loaded one way with 5 tons, it carries 100 ton-miles at a cost of 25 cts. per ton-mile.

However, trucks usually are loaded considerably in excess of their rated capacity, a very common overload for a 1-ton truck being 50 per cent, and for a 5-ton truck 30 per cent. If a 5-ton truck carries 6.5 tons and averages 50 miles a day, which is quite common on road work, it delivers more than 160 ton-miles daily; and if the daily cost is $25, the cost per ton-mile is 15.6 cts.

If a 5-ton truck is rated at 90 miles in 10 hrs., but averages only 45 miles, due to delays in loading, unloading, etc., a similar percentage of lost time would give 75 miles traveled by a 1-ton truck. Hence if a 1-ton truck carries 1½ tons, and travels empty half the distance, it delivers 56 ton-miles a day.

The cheapest of 1-ton trucks costs $800 with a dump body, and is regarded by some road contractors as having a life of only 2 years (although no published records of so short an average life are to be found) or a 50 per cent annual depreciation. If its repair cost is put at 25 per cent, and insurance, interest and taxes at 10 per cent, we have a total of 85 per cent of $800 or $680 annually. If this is spread over 200 days worked annually, we have $3.40 per day for fixed charges and repairs. Then the total daily cost may be estimated, thus:

Fixed charges and repairs	$3.40
7.5 gals. gasoline for 75 miles at 20 cts.	1.50
Oil	0.40
Tires	1.10
Driver	5.00
Overhead expenses	.60
Total per day	$12.00

At 75 miles a day this is equivalent to 16 cts. per mile. At 56 ton-miles per day, this is equivalent to 22 cts. per ton-mile. This cost can not be compared with the above given ton-mile cost of the 5-ton truck, for the latter was assumed to work 265 days a year instead of 200. Since not more than 100 days are usually worked each year by the average road builder's plant, it is evidently either that the trucks should be worked two shifts daily or that work should be secured for them at other times of the year. For example, the trucks may be used for hauling coal in the winter, or for miscellaneous haulage purposes other than road work.

In spite of the fact that a very great deal has been published on the cost of motor truck haulage, accurate cost estimating under different conditions remains very difficult. Too many assumptions as to essential elements of cost (such as depreciation, repairs, average load, average mileage, etc.) have been based on information that is too meagre. What is really needed is a great array of data of actual accomplishment over a period of at least five years, under varying conditions that have been carefully recorded. The above given estimates of trucking costs must be taken merely as illustrative of what certain users of motor trucks regard as being conservative.

It should be remembered that the price of motor trucks has been steadily declining, while the durability and traveling speed have been steadily increasing. Hence cost records that are even a few years old are apt to be very deceptive.

Weight of Materials.—In estimating the weight of a batch of wet concrete, a bag of dry cement weighs 95 lbs. and has a volume of 1 cu. ft. Dry sand, gravel and crushed limestone or sand stone usually weigh about 95 lbs. per cu. ft., or the same as the cement. Hence if a batch is a 1:2:3½ mix, we have 6.5 cu. ft. at 95 lbs., or 618 lbs. If the batch is wet, call the weight 100 lbs. per cu. ft., or 650 lbs. for a 1:2:3½ mix. Hence a 4-bag batch weighs about 2,480 lbs. dry and 2,600 lbs. wet.

The following are the approximate cubic yards per ton of 2,000 lbs.

Ashes	1.75
Coal (bituminous	1.5
Cement (Portland)	0.74
Cinders	1.75
Clay, dry and in lumps	1.2
Concrete, wet	0.5
Earth, moist and packed	0.75
Earth, loose	0.95
Masonry debris	0.8
Rock, crushed limestone	0.85
Sand and gravel pit	0.75

Crushed stone reduces about 10 per cent in volume after being hauled a short distance over a rough road.

INTERNATIONAL HARVESTER COMPANY OF AMERICA

(Incorporated)

606 So. Michigan Ave., Chicago, Ill.

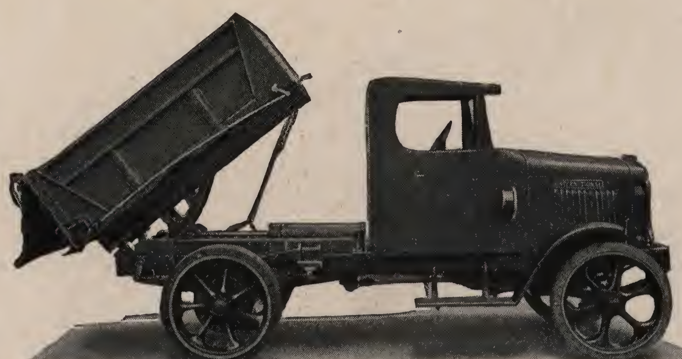
Motor Trucks and Tractors

Products: Motor Trucks, Industrial Tractors, and Industrial Power Units.

International Line: International Motor Trucks are built in ¾, 1¼, 1½, 2, 2½, 3½ and 5-ton capacities. There is a size and type exactly suited to every hauling requirement. The performance and economy of Internationals in road building, excavating and construction work is recognized by contractors everywhere. International trucks are powered for the long, hard pulls and for consistent performance under varying conditions of road and load. Records of 75,000 to 300,000 miles of profitable operation prove the unusual endurance qualities of these trucks.

Model SD, 2-tons rated capacity, with gravity dump body, wheelbase 117 inches, tire equipment 30x5 front, 32x6 rear, heavy-duty truck cord tires. This model is available with either 4 or 6-cylinder engine

Special Dump Truck Models: International trucks are particularly adapted to dump truck work. They meet the widespread demand for trucks that will stay on the job and deliver dependable, low-cost service. There are special dump models with either double-reduction gear or chain drive in 2½ and 3½ tons capacity and a chain drive model of 5 tons capacity. The Model SD is adapted to that class of dump truck hauling where speed is important and its sturdy construction assures long truck life.



Model 54 double-reduction drive truck, 2½ tons capacity with dump body and underbody hoist. All heavy-duty models are available in several wheelbase lengths and with tire equipment to meet the users' requirements

Heavy-Duty Construction: International heavy-duty trucks are equipped with powerful, compact, and efficient four-cylinder engines. International frames are pressed steel channels, varying in depth from 6 to 8 inches, well braced by numerous channel and tubular cross members. Cast steel wheels are regular equipment. Every unit is properly coordinated with the others resulting in low-cost ton-miles over long periods of years. Accessibility of all units facilitates easy adjustment and replacement of parts when necesssary.

Chain Drive Dump Trucks: Models 54-C, 74-C, and 104-C are chain drive trucks ranging in capacity from 2½ to 5 yards. The frames of the chain drive models are reinforced by a second channel extending from dash to end of frame on each side. Convenient and practical chain adjustments is incorporated in the radius rods.

Model 74-C with 4-yard dump body and underbody hoist. Wheelbase 154 inches, tire equipment 36x6 front, 40x12 rear, solid tires. Models 54-C and 104-C are of the same general design for 3 and 5-yard loads respectively

Double-Reduction Drive Trucks: Models 54 and 74 are double-reduction drive trucks of 2½ and 3½ tons capacity. The herringbone gear type of drive assures quiet, efficient operation.

After-Sale Service: International Harvester maintains 142 company-owned branches and service stations located in principal cities, and International motor truck dealers located in all sections. International owners know that when emergencies arise, service facilities are available which assure the utmost promptness in meeting their requirements.

MACK TRUCKS, INC.

INTERNATIONAL MOTOR COMPANY

25 Broadway, New York, N. Y.

Manufacturers of Mack Trucks, Mack Busses, Mack Fire Apparatus, Mack Rail Cars

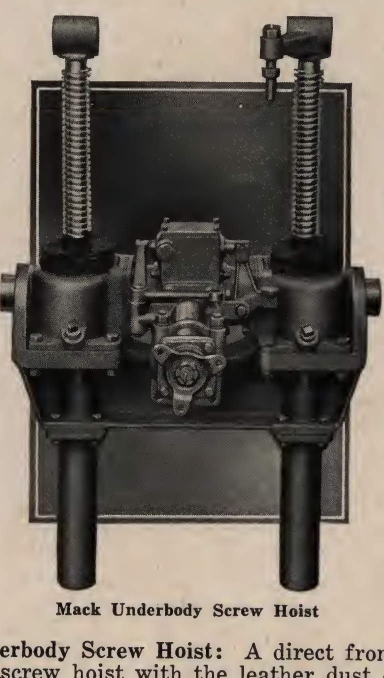
FOR ONE HUNDRED FIVE DIRECT FACTORY BRANCHES SEE GEOGRAPHICAL INDEX

Mack Model AC Dump Truck

Contractors Special Dump Truck

Mack Model AC Dump Truck: All Mack Standard Steel dump bodies are made up of two interchangeable halves joined at the center, leaving a smooth rounded surface where sides and bottom meet. The illustration shows a body designed exclusively by Mack. It has all the standard Mack steel body features, with the additional advantage of a renewable floor. The floor of a contracting body is subject to severe distortional shocks and abuse but when the floor is renewable the length of life of the body is materially increased.

The Contractors Special Dump Truck: The Mack Contractors' Special has an all steel rounded bottom dump body designed specially for road builders. One partition is standard. Tail gate is double acting and spreader chains are furnished when desired. Note the heavy gusset plates and protective steel running board on sides, features that add to the sturdiness and long life of the body.

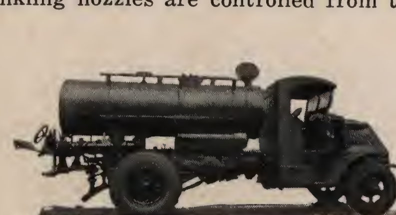


Mack Underbody Screw Hoist

Mack Underbody Screw Hoist: A direct front view of the Mack screw hoist with the leather dust covers let down in order to expose the sturdy screws. The Mack hoist is extremely light in weight and operates at a higher speed than any other hoist now in regular production. The body may be elevated to a full 45° dumping angle in 20 seconds with the engine turning at 1000 r.p.m. All parts run in oil and the screws receive an oil bath before the body is raised. It has the added advantages of a straight line drive direct from the truck transmission and will hold the load in a permanent position.

Mack Flusher and Sprinkler

Mack Flushers and Sprinklers: Mack Flusher and Sprinkler Equipment either in combination or in separate units has been built by this company for many years and is offered in a variety of models to meet varied specifications. The illustration shows a 1000 gallon tank with separate engine for operating the centrifugal pump also an auxiliary fire-fighting attachment is part of the equipment. In this unit the flusher and sprinkling nozzles are controlled from the driver's seat.



Mack Road Oiler

Mack Road-Oilers: Great numbers of these roads oiling units are in service by State, County and Municipal Highway Departments not only in the construction end of the work but in maintenance.

For descriptive literature write to: Advertising Department at the above address.

Cable Address
"Lee Line"
Plymouth, Ind.

LEE TRAILER & BODY COMPANY

Main Office and Factory, 1108 Lee Road, Plymouth, Ind.

Motor Truck Trailers, Side and End Dumping Bodies in Three Types

STANDARDIZED IN FIVE STYLES FOR EACH TYPE

(1) LEE-MOTOR LIFT (2) AUTOMATIC GRAVITY (3) SEMI-AUTOMATIC HAND HOIST

Branch Office in Canada: Dominion Truck Equipment Co., Kitchener, Ont.

Products: Motor Lift, Automatic Gravity, Semi-Automatic Hand Hoist, Side and End Dump Bodies, Trail-a-Dumps, Trailers, Semi-Trailers, Logging and Stone Boat Trailers, Integral, Single and Double Drop Frame Trailers; Four Wheel Reversible and Non-Reversible Trailers.

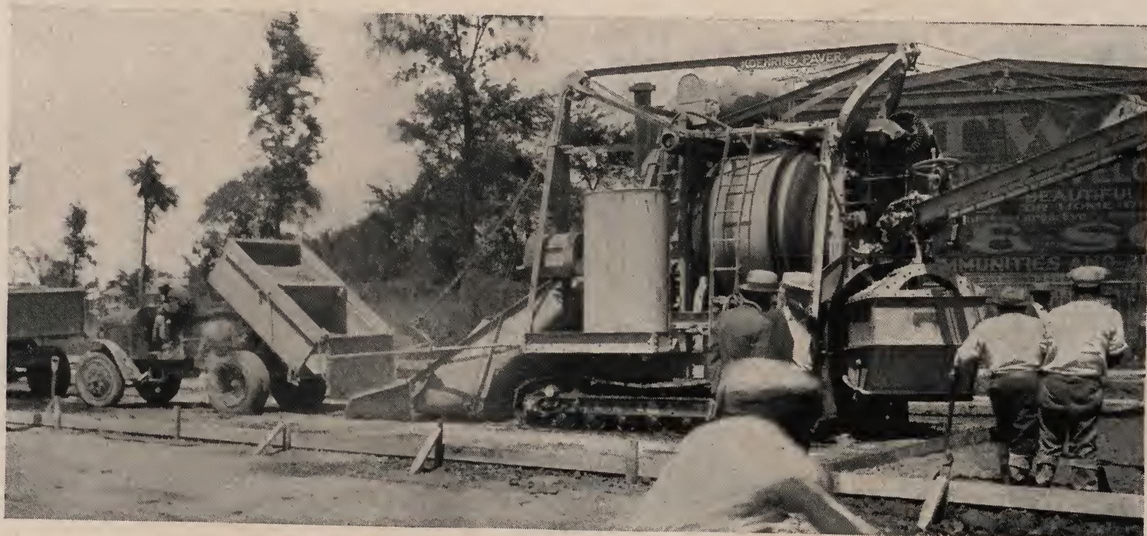
Lee Dump Bodies—For both double batch and single batch loads.

LEE

Lee-Motor-Lift—A mechanical hoist that needs no oil or grease other than for lubrication.

Busy building paved roads since 1918.

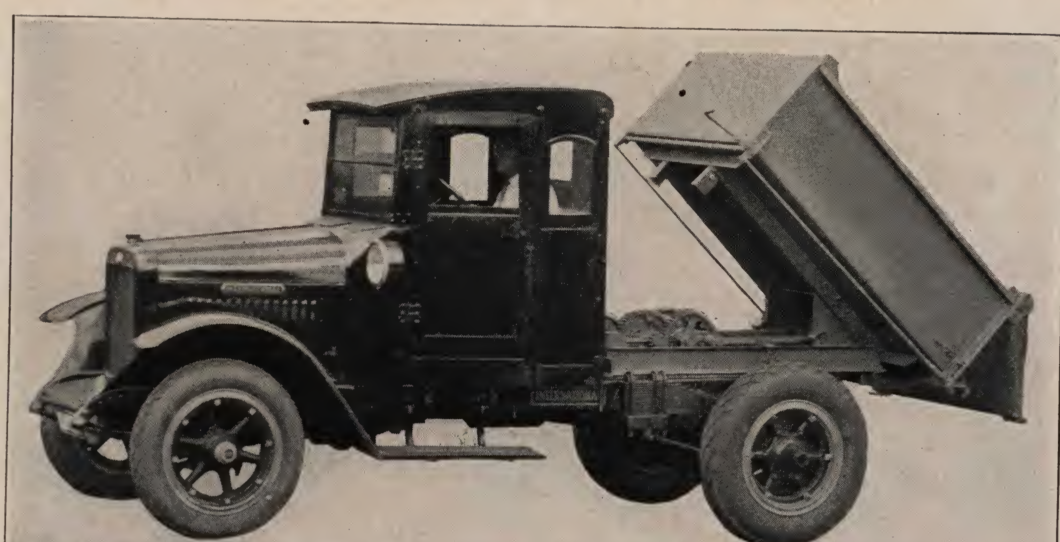
Lee Automatics equipped with tailgates for spreading gravel. Rugged and well balanced. No small wearing parts.



Lee Automatic Dump Bodies Are Built for All Makes of Speed Trucks, Including Chevrolet and Ford

Lee Bodies and Hoists are especially designed for the Hauling Requirements of Paving Contractors and Road Builders using High Speed Dump Trucks.

Write for catalog and price lists covering large capacity truck bodies, including Chevrolet and Model AA Ford.



Gear Covering Removed to Show Hoisting Mechanism
Lee Motor-Lift Single Batch Dump Body. Built for All Makes of Trucks

HYDRAULIC HOIST MANUFACTURING CO., INC.

292 Walnut St., St. Paul, Minn.

Hydraulic Hoists

Representatives: Catalogs, prices, working data, expert advice and service on St. Paul Hydraulic Hoists may be had quickly by getting in touch with any of the following representatives:

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Allentown, Pa., V. H. Steckel, 302 S. West St.
Atlanta, Ga., Drennen & Zahn, 449 Marietta St.
Baltimore, Md., Peters Auto Body & Spring Works, 410 Ensor St.
Birmingham, Ala., Drennen Motor Car Co.
Boston, Mass., Perin-Walsh Co., 1540 Columbus Ave.
Buffalo, N. Y., Truck Equipment Company, 1791 Fillmore Ave.
Cincinnati, Ohio, Lawrence Bruder Co., 211 W. 2nd St.
Cleveland, Ohio, The Ohio Truck Body & Wagon Co., 3291 E. 65th St.
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Davenport, Ia., Carleton Motor Company, 417 W. 3rd St.
Denver, Colo., Timpte Brothers, 3rd at Market St.
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Pittsburgh, Pa., The Schnabel Company, South Tenth St.
Portland, Ore., Earl B. Staley Co., Adams and Pacific Sts.
Providence, R. I., Providence Body Co., 128 Narragansett Ave.
Roanoke, Va., Roanoke Welding Co., 16 Kirk Ave.
Salt Lake City, Utah, Lund Co., 419 Dooly Block.
San Francisco, Cal., Nugent Covey Wagon Co., 53 Duboce Ave.
Savannah, Ga., Stewart Mongeau Motor Co., 213 Broughton St. N. E.
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St.Paul VERTICAL AND UNDERBODY HYDRAULIC HOISTS

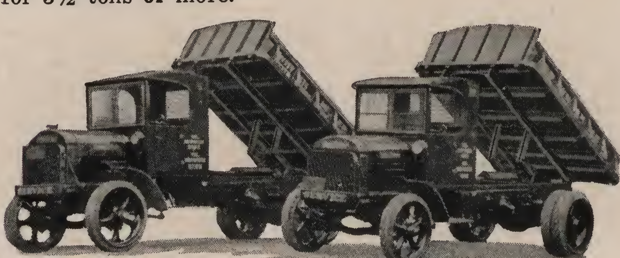
Products: Vertical and Underbody Hydraulic Hoists for Motor Trucks.

Experience: The Hydraulic Hoist Manufacturing Co., Inc., was a pioneer in the building of hydraulic hoists for motor trucks. The first hoist, installed in 1912 on a Northwestern Fuel Co.'s truck (St. Paul, Minn.), is still in operation. This 16 years' specialized experience with high-grade hoists is at the disposal of all users of dumping trucks.

Types and Sizes: The hoists are made in two types, vertical and underbody. Vertical hoists are made in two sizes: The Light Duty size for trucks with a rated capacity of 3 tons or less, and the Heavy Duty size for rated capacities of 3½ tons or more. Underbody hoists, which have a horizontal cylinder with lifting arms connected to the body, are made in three sizes: The Light Duty, for trucks with a rated capacity of ¾ to 1½ tons; the medium duty for 3 tons or less, and the Heavy Duty for 3½ tons or more.

General: St. Paul Hydraulic Hoists are designed for difficult, exacting work. The first hoist has worked continuously, dumping gravel and coal, summer and winter through temperatures from 100 above to 30 below. The care in manufacture guarantees a compact long-lived dumping unit which is simple to operate. Every hoist is tested beyond its rated capacity. All hoists are built to standard specifications, for individual makes and models of trucks.

TYPE	VERTICAL		UNDERBODY		
SIZE	Light Duty	Heavy Duty	Light Duty	Med. Duty	Heavy Duty
CYLINDER DIAMETER	5 inches	6 inches	5 inches	6 inches	8 inches
ADAPTED TO TRUCKS HAVING A RATED CAPACITY OF	3 tons or less	3½ tons or more	¾ to 1½ tons	3 tons or less	3½ tons or more
MAXIMUM LIFTING STRENGTH	6 tons	15 tons	3 tons	6 tons	15 tons
HORSE-POWER REQUIRED	2 to 3	3 to 4	1½ to 2	2 to 3	3 to 4
PISTON TRAVEL	36 inches	38 inches	20 inches	22 inches	22 inches
CHASSIS SPACE REQUIRED, CAB TO BODY	10 to 12½ inches	12 to 15 in.			
APPROXIMATE FRAME SPACE REQUIRED			55 inches	62 inches	10[illegible] inches
SPACE REQUIRED BETWEEN CHASSIS FRAME AND BODY (UNDERBODY)			10½ inches	13 inches	12 inches
HEIGHT OVER ALL (VERTICAL)	60 inches	62 inches			
AVERAGE WEIGHT	500 lbs.	625 lbs.	390 lbs.	625 lbs.	850 lbs.
CODE WORD	PIKE	PEAK	STAR	SILO	SKIP



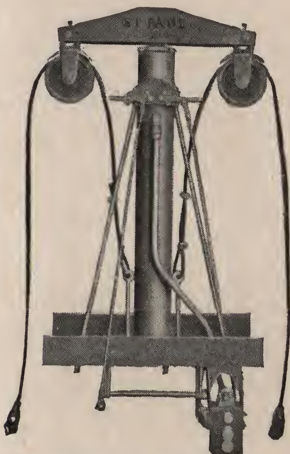
Part of a fleet of American LaFrance Trucks Model Y equipped with St. Paul Heavy Duty Underbody Hydraulic Hoists. These trucks belong to Whynn & Miller Contractors, Westchester, N. Y.

Picture shows a few White Trucks belonging to the Cuyahoga County Ohio Road Dept. These are also equipped with St. Paul Heavy Duty Underbody Hydraulic Hoists.

Continued on Next Page

Vertical Type of Hoist: The vertical type is fitted to bodies in which a small portion of the length may be more readily spared. A fore-and-aft space of 10 to 12½ inches is required for the light duty, and 12 to 15 inches for the heavy duty sizes.

Cylinder: The cylinder is made from selected extra-heavy pipe, machined in three operations: Rough boring, finishing and final grinding. The closest tolerances are maintained. A gray iron piston with two rings is used. Mounted upon this is an equalized crosshead which provides for unequal body loading and relieves distortion. A copper tube acts as an air vent and excludes foreign matter from the oil chamber.



Heavy Duty St. Paul Vertical Hydraulic Hoist

Sheave Hangers: Upon the outer ends of the crosshead are pivoted the hangers which carry the cable sheaves. They are made of electric steel castings of ample strength, so constructed as to make a ball and socket joint. This gives great strength, insures long life, dependable operation. The ball joint provides flexibility, saves cables and relieves strain on the piston tube.

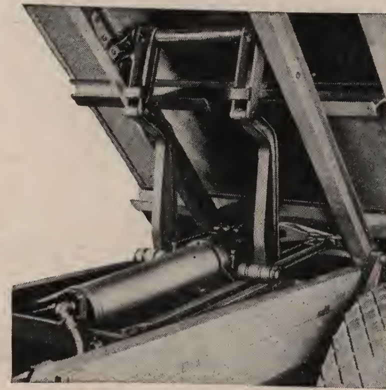
Base Plate and Supports: The cylinder is mounted upon a base plate on extra heavy angles. The base is machined drop forging. The angles are turned inward to save space; this type of hoist can be mounted in less space than any other.

Pump Details: The pump bracket is a steel casting which supports the pump firmly on both sides and is attached to the support angle. Pump is manufactured with extreme care from selected materials. Pump body is of finest gray iron; gears are cut on Fellows' shapers to insure accuracy; shafts are case hardened and ground; bushings and valves are high-quality bronze; gears and valves are hand lapped to a perfect fit. Pump may be top or bottom drive and run clockwise or counter-clockwise. Pump will deliver maximum efficiency at 500 to 600 r.p.m. On light duty hoist 2 to 3 h.p. is required; on heavy duty 3 to 4 h.p.

Power Take-off: The pump is driven by horizontal shaft from the power take-off, designed to be attached to and driven through the truck transmission. It is made with or without filler block and for S. A. E. standard openings, as well as for many special openings. These sturdy units have heat-treated gears and shafts, the shafts case-hardened and ground to insure long life. Bearings and shifter forks are of high quality bronze.

Underbody Type of Hoist: The underbody type is fitted to chassis in which length cannot be spared. The hoists require 56, 62 and 106 inches chassis space, and 10½, 13 and 12 inches, respectively, between frame and body. The same high-class construction with ground cylinder bore is used. The crosshead of self-compensating type is mounted at the rear end of the light and medium duty sizes and forward on the heavy duty size.

Lifting Arms and Action: The lifting is a powerful wedge action, working through rollers. This gives maximum leverage with minimum oil pressure. It reduces strain on hoist and truck frame. The lower bearing is below the top of the chassis, so there is no dead center. The arms are fastened to the body forward of center to prevent twisting. The twin tracks for rollers stabilize the lifting arms when raised. On the largest size pull arm and lifting arm are cast integral and a powerful crank action leverage obtained. The main shaft has three bearings.

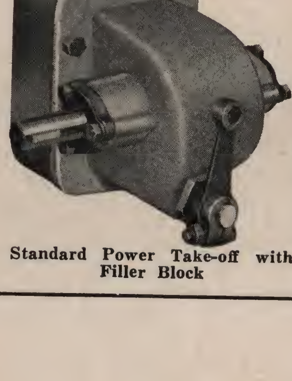


Close Up of Medium Duty St. Paul Underbody Hydraulic Hoist

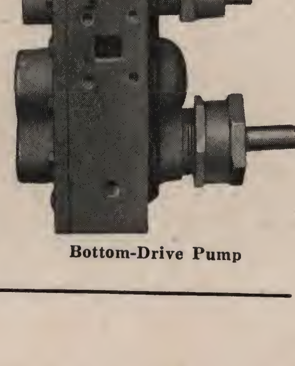
Support and Pump: No subframe is required, the bearing brackets being fastened to frame side members, pump bracket and other units to cross members. This decreases weight and simplifies the mounting. Pump, bracket, speeds, power take-off and power consumption are the same as on the vertical type.

Application and Interchangeability: Specially designed assemblies fit each individual make and model of truck, and required variations are incorporated in the manufacture. Each is shipped complete, with power take-off, universally-jointed shaft, clamping blocks and all other parts. There are no extras to buy. Driving parts for vertical and underbody hoists are fully interchangeable.

Heavy Duty St. Paul Underbody Hydraulic Hoist



Standard Power Take-off with Filler Block



Bottom-Drive Pump

DITWILER MANUFACTURING CO.

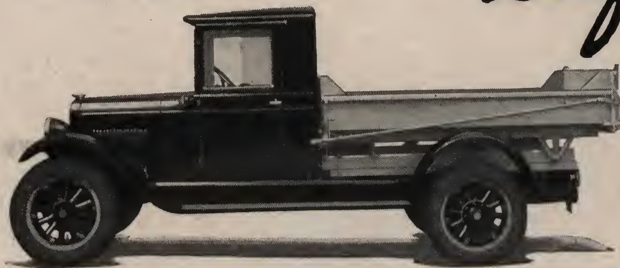
Galion, Ohio

Manufacturers of HERCULES-DITWILER Saftee Steel Dump Bodies

Chevrolet Dump Bodies Distributed Through Hercules Products, Inc., Evansville, Ind.
71 Distributors in United States and Canada

Products: DUMP BODIES—AUTOMATIC AND HAND HOIST, POWER HOIST, OPEN BOTTOM TYPE DUMP BODIES, SPECIAL TYPE STEEL BODIES.

Saftee



Power Dump

New Power Dump L-1 No. 957: Power dumping for one and two ton trucks is now made possible through the development of power take-off attachments applicable to small trucks, and the development of the Hercules-Ditwiler mechanical Power dump, simple in construction and moderate in price.

This power dump employs a rack which elevates and lowers the body by means of power transmitted through an irreversible worm and gear combination. Operation is entirely controlled from driver's seat.

Since power must be utilized to lower the body as well as raise it, the body will not drop down if the power is accidentally or intentionally cut off. Shut-off is automatic at dumping angle and upon return of body.

Hoisting and reversing gear is enclosed in a grease tight case, providing proper lubrication and dust exclusion to all moving parts.

An engine running 1000 r. p. m. will raise the body to an angle of 55° in one-half minute; ground clearance equals height of chassis.

Speed, safety, ease and economy of operation render this power dump practical in all work where a dump body can be utilized.

G-1 No. 954 Hand Hoist: The only entirely safe operating Hand Hoist dump body manufactured. It has no crank handle to lose or kick back and the body is dumped and returned with absolute safety to the operator.

It locks itself in any position—is self locking. It has no chains, cables, ratchets or exposed gears. It operates through worm gears.

Mechanism is entirely enclosed and packed in grease, which means protection from pebbles, sand and grit, road dust, snow and ice.

Tail gate is held at any angle by adjustable chains. Dumps smoothly; no strain or racking action on chassis.

Recommended for coal deliveries, construction and excavation work, road building, especially spreading and repairing, and for work around cemeteries, farms and golf courses.

Hand Hoist

New Bottom Dump No. 959: Approximately 300 pounds lighter than other bodies of same steel construction and size, this type allows that much more load capacity.

Dumps at any rate of speed without damage to truck or frame, as there is no jar in dumping.

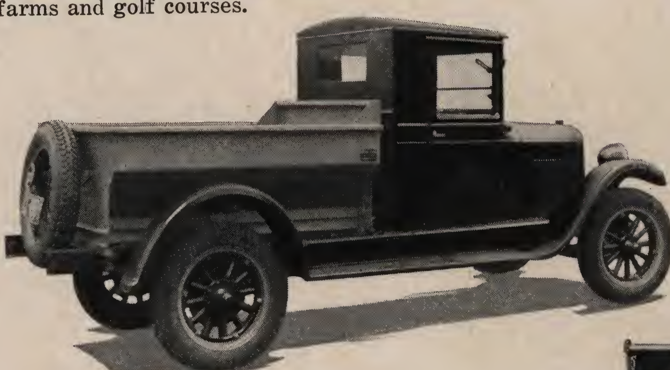
Entirely controlled from driver's seat.

Spreads regularly as wide as wheel tread.

Thickness of spread can be regulated by speed of truck.

Low body is a great help in hand loading or backing under a low or movable hopper.

Especially adapted for road building and repairing, for hauling crushed rock up to 8 in. size, creek gravel, sand, ground limestone, coal, coke and all kinds of grain, etc.



Bottom Dump

GA-1 No. 955 Automatic: The body dumps and returns without driver leaving his seat.

The body is mounted so that two-thirds of the weight of the load is ahead of the rear axle.

The double acting tail gate releases and locks automatically.

Essential in road building—in fleet operation. Preferred for handling stone, gravel and the like and in the removal of earth from grades and excavations.

Automatic

THE HEIL COMPANY

1138-60 Montana Ave., Milwaukee, Wisconsin

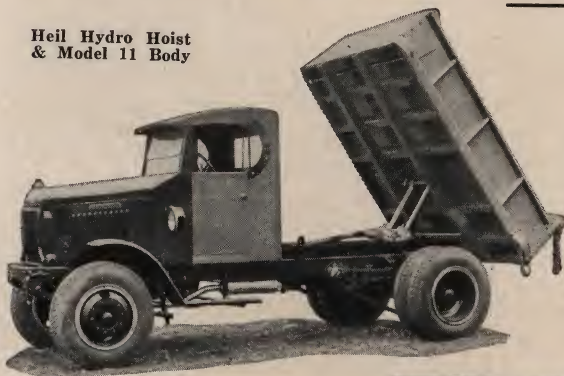
Truck Hoists and Bodies, Snow Plows, Sprinklers and Tanks

Direct Factory Branches at New York, Philadelphia, Boston, Cleveland, Detroit, Chicago

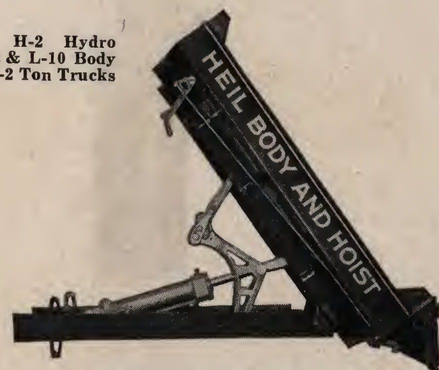
DISTRIBUTORS:

Arizona Tractor & Equipment Co., Phoenix, Ariz.
General Auto Truck Co., Washington, D. C.
Heil Northwestern Sales Co., St. Paul, Minn.
Kelly Special Body Co., York, Pa.
Kranz Automotive Body Co., St. Louis, Mo.
The Cope Co., Irvington, N. J.
Maryland Truck Equipment Corp., Baltimore, Md.
Mayer Body Corp., Pittsburgh, Pa.
Modern Vehicle Co., San Francisco, Calif.
New Mexico Road Equipment Co., Roswell, N. Mex.
Shop of Siebert, Toledo, Ohio.
Sid. Schultz, Louisville, Ky.
H. G. Smith & Bros. Co., Scranton, Pa.
Smith-Moore Vehicle Co., Richmond, Va.
Steffen-Van Steenwyk Co., Sioux City, Iowa.
Six Wheels, Inc., Los Angeles, Calif.
Hall-Perry Machinery Co., Butte, Mont.
Watkins Commercial Body Corp., Buffalo, N. Y.
Wilson Machinery Co., Denver, Colo.
J. W. Bartholow Co., Dallas and Ft. Worth, Texas.
Hooper Equipment Co., Indianapolis, Ind.
New Orleans Equipment Co., New Orleans, La.

Heil Hydro Hoist & Model 11 Body

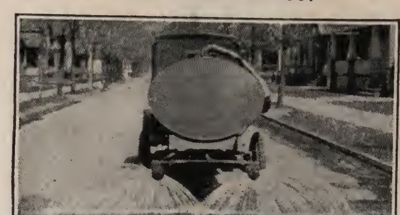


Heil H-2 Hydro Hoist & L-10 Body for 1-2 Ton Trucks

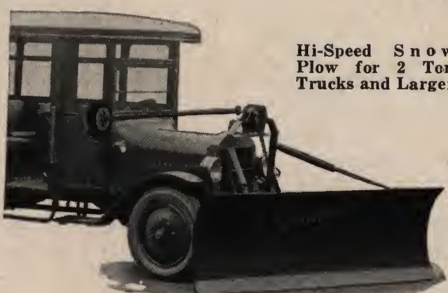


Heil Hydro Hoists are simple in design, sturdy in construction, rapid in operation and easy to install on any truck. Only two revolving parts and these operate in a bath of oil. The twin cylinder unit is the most powerful truck hoist made—you can't overwork or overload a Heil Hydro. It is the most rapid heavy duty hoist—dumping a full load in less than fifteen seconds. It mounts at the strongest part of the chassis frame. No adjustments are necessary—no cams, rollers or sheaves to cause trouble. The pump is an integral part of the hoist—no piping to develop leaks. The only hoist sold under a written two year guarantee. Send for bulletins 160 and 178.

Street Sprinklers of 500 gallons capacity for mounting on Ford, Chevrolet and other light duty trucks. Requires only several hours to install ready for service. Send for bulletin 159.



Hi-Speed Snow Plow for 2 Ton Trucks and Larger



Patented Heil Batch Boards

Heil Bodies and Batch Boards. Heil bodies are available in a large number of designs—one for every type of hauling. Sturdy, reinforced construction built to last. Completely illustrated and described in Body Catalog. Heil Batch Boards with the patented easy to operate eccentric action cannot be duplicated. Installed on any style of body for coal, sand, gravel and road building work.

Heil H-2 Hydro Hoist is a rapid, sturdy, compact, simple, complete dump unit for mounting on any 1, 1½, 2 ton truck. Mounted with either Heil L-10, L-11 or L-51 and L-52 bodies, by use of four to six U-bolts. Not necessary to drill any holes in the truck chassis. Dumps in five to nine seconds. Dumping angle 56 degrees, ground clearance above chassis frame. Send for H-2 bulletin.

Hi-Speed Snow Plow for mounting on any 2 ton truck or larger. Will do same work, and quicker, than plows weighing 1,000 lbs. or more on heavy duty trucks. Will handle snow at 35 miles per hour. Many unique features, including special tripping action. Send for bulletin 183.

Hand Hoist Dump Units are available in three different body models for mounting on all light duty trucks. All hoist gears are machine cut—easy to operate. Two way locking pawl—special brake to control rapid lowering of body. Body cannot tip back—secured to hoist. Can be installed in a few minutes. Send for bulletin 161.

FRUEHAUF TRAILER COMPANY

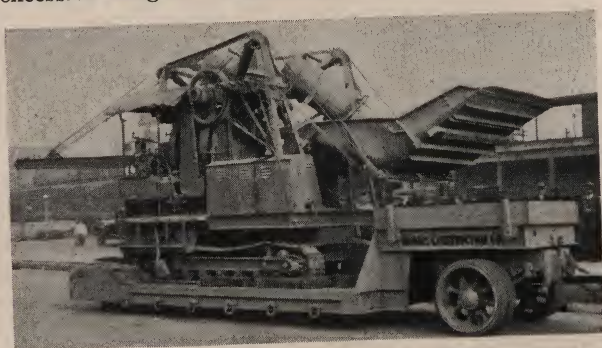
10951 Harper Avenue, Detroit, Michigan

Telephone: Whittier 3481. Cable Address: "FRUTRAILCO"
Branches and Distributors in All Principal Cities

Semi-Trailers, Four-Wheel Trailers, Carryalls, Pipe and Pole Trailers

Experience: Oldest and Largest Manufacturers of Trailers. Fruehauf leadership is your guarantee of record-breaking reductions in haulage costs. Your investment in a Fruehauf Trailer gives you the satisfaction always enjoyed by those who buy the best.

Most contractors can make profitable use of a general-purpose Carryall. That's why the Type "D," shown below, is selling in such tremendous volume. It's designed and built for all-around utility. Two wheels in front—four low wheels in rear. Massive without excessive weight. Engineered to "stand the gaff" of



This Type "D" Fruehauf Carryall is Owned and Operated by the Brooks Construction Company of Ft. Wayne, Indiana

hard, heavy going. Backed by a performance record that merits your confidence. Lowest, most convenient height for side or rear loading. Platform entirely clear for load—free from wheels or wheel housings.

Seven Standard Types: Seven standard types of Fruehauf Heavy-Duty Drop-Frame Carryalls are available to you—with capacities ranging from 10 to 60 tons. Each of these seven types is equipped with radius rods—insuring the proper alignment of wheels at all times. All frames and gears are hot riveted.

Bolster plates are made of cast steel, hot riveted to the main frame and gear frame so that all pulling stresses are taken through a 4" diameter boss. These plates are provided with a heavy bronze bushing, grooved for Alemite lubrication—and, when worn, it is only necessary to replace the bushing. King pins are used only to hold the gear frames to main frames.

Each Fruehauf Carryall is equipped with Timken Bearings—adjustable for wear.

Large roller-bearing circles, mounted between the front gear and frame, make steering an easy matter, even under the heaviest load. With the full cut-under gear, each of these Carryalls can be turned within the length of its wheelbase—a feature that is much appreciated by practical haulers.

Due to city and county legislation, it is essential in most localities to transport "on rubber" all heavy machines with metal wheels—insuring the proper protection for roads and paved streets.

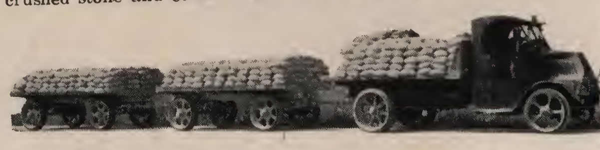
Rolling a production unit over the road on a Fruehauf Carryall protects it from vibration—keeps it in shape to work at top speed on productive jobs—and, by doing away with "holdups" for repairs, lessens maintenance expense, keeps crews busy and results in more work at less cost.

Special Models: The seven standard types of Fruehauf Carryalls meet most heavy-haulage needs. Should your requirements demand a change in specifications, we are prepared to build Carryalls to your special order. The advice and counsel of Fruehauf Engineers are always available.

Low-Cost Haulage of Materials: Mark R. Hanna, well known Paving Contractor of Detroit, easily doubles the carrying capacities of his motor trucks with Fruehauf 4-Wheel Trailers—like the one shown above. The 3-yard dual hoppers give him a total of 6 yards of material on the Trailer alone. There is no delay in keeping equipment and man power busy for lack of supplies. The number of expensive motor trucks to serve his needs is cut in two. The payroll to keep supplies on hand is cut in half while operating costs are reduced more than 75%.

This unit is found particularly efficient in emergencies, such as handling enough materials to finish a run or in getting materials to a certain job on rush order. Progressive Contractors cannot afford to be without this great help.

This type of Trailer may be had with reversible gears on each end which permits the operator to draw from either end. This saves time in making turns in narrow quarters that are frequently encountered in paving operations. When such conditions are known to be absent, a non-reversible Trailer may be used. Both types are operated to a great extent in the handling of sand, gravel, crushed stone and other construction materials.



The George F. Alger unit, shown above, represents the utmost in haulage efficiency. **Three times** the cement ordinarily handled by cement trucks is being easily transported on this truck-and-trailer combination. 600 bags or 150 barrels of cement are carried to the job with one motor truck, one driver and two Trailers. The savings effected are astounding. On the average 15-mile haul, 3/5 of one cent per barrel per mile is saved. A total of $11.50 per trip. Four trips a day mean a saving of $46.00. In a year's time of 288 working days, the saving this unit makes would purchase another motor truck, two Trailers, pay the driver's wages, and have money left!

An additional service that this Contractor renders to Road Building Contractors, which they in turn use in further reducing their own costs, is the scheme of leaving the first two Trailers loaded as platforms or storage piles at the job during the day. This eliminates the expense and bother of special platforms and reduces the number of handlings otherwise required.

These 4-Wheel Fruehauf Trailers are available in the reversible or non-reversible types.

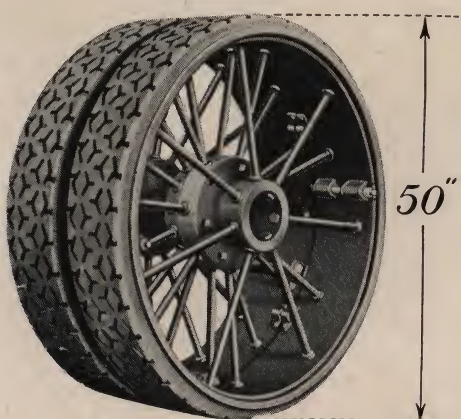
FRENCH & HECHT

Davenport, Iowa - Springfield, Ohio

Built-up Steel Wheels

Products: Built-up Steel Wheels for Tractors, Industrial Equipment, Graders, Maintainers, Drags, Scarifiers, Scrapers, Concrete Mixers, Stone Crushers, Drills, Air-Compressors, Hoists, Trailers, and Other Road Building and Maintaining Equipment. Grader Hand Wheels.

Also Built-up Steel Expansion Wheels with Rubber Tires for Tractors, road building and maintaining machinery of all kinds, baggage trucks, highway mowers, wheelbarrows, trucks, trailers, busses.



20 INCHES WIDE

50x10 Duals built-up Steel Expansion Wheels for McCormick-Deering 15-30 tractors and many other makes.

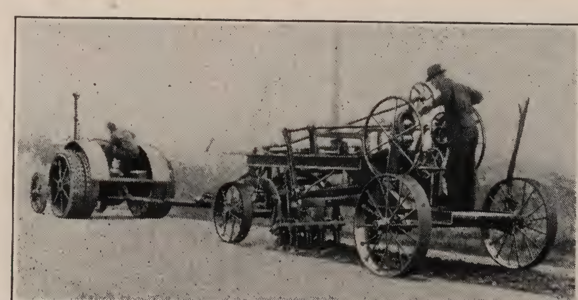
Various sizes of expansion wheels for rubber tires are produced to meet all wheel requirements. Auxiliary wheel weights, giving any desired weight and traction, are provided. In this manner the highest traction efficiency can always be maintained with French & Hecht wheel equipment.

No Power Press is required to mount on or remove the large rubber tires from the wheels. This is a noteworthy feature of all French & Hecht Wheels with rubber tires.

The steel wheel rims are equipped with expanding wedges that make it possible, with the use of a hammer and an ordinary wrench to mount or remove rubber tires anywhere and at any time.

The steel spokes of French & Hecht built-up wheels are forged while hot into the hub and have heads formed on the inside of the hub and shoulders on the outside.

French & Hecht Wheels are made mechanically correct for all applications. For this reason, French & Hecht wheels are extensively used on power graders where strength and traction efficiency are important factors in the wheel equipment.



Most of the leading makes of machines used for highway construction and maintenance are equipped with French & Hecht Wheels. French & Hecht is the largest organization in America specializing in the development, design and manufacture of steel wheels exclusively.

INTERNATIONAL HARVESTER COMPANY OF AMERICA

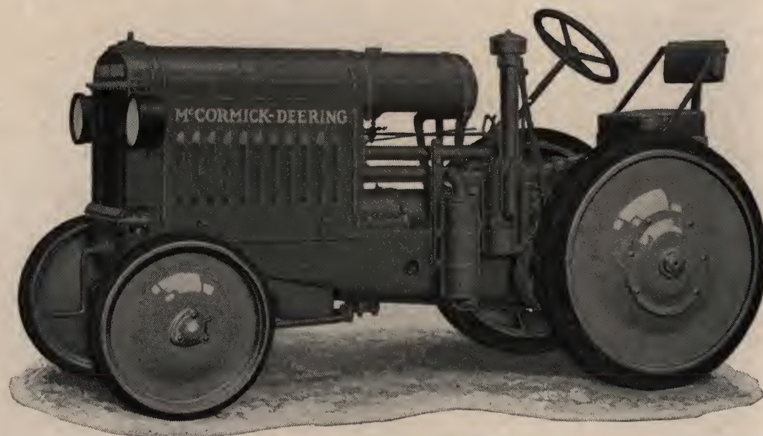
(Incorporated)

606 So. Michigan Ave., Chicago, Ill.

Industrial Tractors and Motor Trucks

Products: INDUSTRIAL TRACTORS.

The McCormick-Deering Industrial Tractor: This industrial tractor was specifically designed for industrial municipal, highway and commercial service. The McCormick-Deering is performing with satisfaction, in constant service, on both state highway construction, and maintenance throughout the entire country. Shovels, clamshells, graders, excavators, scarifiers, and all forms of equipment operated from the drawbar, show increased efficiency when powered by the McCormick-Deering.



Road and street equipment of all kinds is operated by McCormick-Deering Industrial Tractors

Adaptability: The McCormick-Deering has a wider range of adaptability than other tractors, as it can be equipped to supply power through the power take-off or belt as well as at the drawbar. The drawbar and the power take-off may be operated either independently or in unison.

Outstanding Features: The McCormick-Deering Industrial Tractor embodies such outstanding features of modern design as directly improve performance, durability, accessibility and economy. All working parts are completely housed to keep lubricant in and dirt out. The main frame construction forms a rigid and substantial foundation for carrying the units. The crankshaft is of rugged construction, heat-treated for enormous strength and mounted on two heavy-duty ball bearings. Lubrication of bearings is certain and bearing replacement simplified with necessity for replacement rendered remote. The cylinders are individually removable and easily and economically replaced when compared to the replacement cost of an entire cylinder block on the conventional tractor engine. There are no chains and no exposed moving parts. The front end is spring mounted to the front axle, which is a great protection to the engine and other units.

Equipment: A highly efficient, fly-ball, centrifugal type of governor is built into the engine which assures a steady uniform flow of power at all times, with an ample reserve for the hard pulls. An air cleaner is standard equipment, which by preventing the entrance of dust to the combustion chambers, effects an appreciable saving in elimination of carbon deposits, scored cylinders, bearing, and other troubles. Disc wheels with rubber tires are standard equipment, however, special wheel equipment is available. A power take-off is also available for delivering power to the pulled machine.

Industrial Power Unit: The engine used in the industrial tractor is also available with base mounting, control panel and clutch in the form of the McCormick-Deering Industrial Power Unit.

International Harvester Service: This extensive organization covers the entire country, serving the user through 92 company-owned branches and thousands of dealers where parts are immediately available. Catalog and information on request.

The McCormick-Deering Industrial Tractor powering an excavating shovel

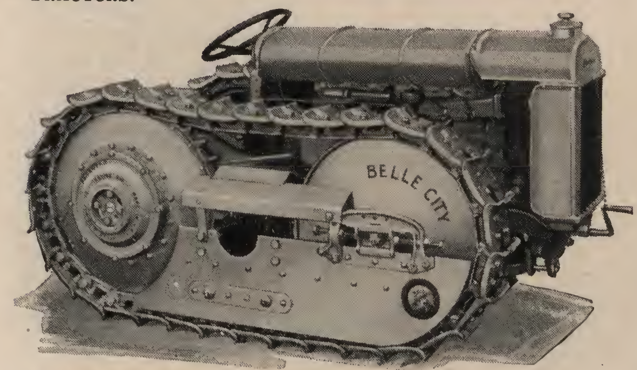
McCormick-Deering Industrial Tractors operate road equipment in every state

BELLE CITY MANUFACTURING CO.

Racine, Wisconsin

Belle City Crawlers for Fordson Tractors

The Product: A CRAWLER ATTACHMENT FOR FORDSON TRACTORS.



Clutch Controlled—Two Models

Standard Gauge—Weight, 2,730 lb. (Crawler only). Inside of tracks, 38 in. Length, 91 in. (Complete). Outside of tracks, 58 in. Height, 52 in. (Complete).

Narrow Gauge—Weight, 2,600 lb. (Crawler only). Inside of tracks, 29 in. Length, 91 in. (Complete). Outside of tracks, 49 in. Height, 52 in. (Complete).

Differential Controlled—One Model.

Standard Gauge—Weight, 2,575 lb. (Crawler only). Inside of tracks, 38 in. Length, 94 in. (Complete). Outside of tracks, 58 in. Height, 52 in. (Complete).

Belle City Crawlers convert the Fordson Tractor into a two ton, sure footed means of traction under all kinds of soil and weather conditions where wheel traction would be impractical or impossible, in sand, gravel, mud, snow, marshes, etc. Low in original cost; low cost of upkeep; buying several Belle City outfits for the same cost of a large crawler gives you more flexibility of equipment and takes you out of the "one job" class; more consecutive hours of service throughout the year; approximately 1,000 sq. in. of ground contact; 50 to 100% increase in drawbar pull; low center of gravity.

Clutch Controlled—Driven and steered through multiple disc clutches in driving sprockets. Fordson differential is locked, making of it a solid driving axle with full power of motor on one or both tracks, whether driving straight ahead or on curves or short turns, regardless of speed or work done. Few adjustments—all parts easily accessible.

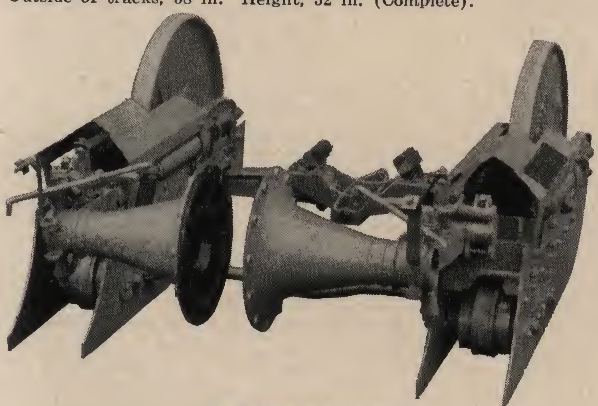
Narrow Gauge—Particularly adapted for plowing, orchards and vineyard cultivation, logging, etc., and where limitation in width is desirable.

Standard Gauge—Built purposely for use with all kinds of industrial equipment—back fillers, graders, loaders, hoists, cranes, snow removal, belt power work, etc.

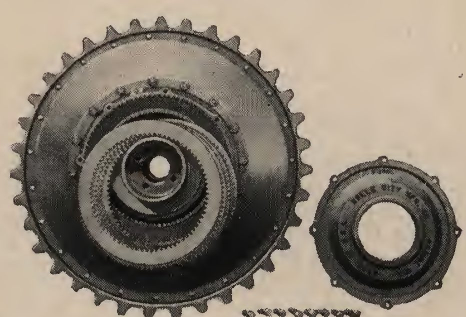
Differential Controlled—One Model.

Standard Gauge for straight tractive work, one man graders, scarifying, belt power work, etc.

Belle City Crawlers are made up of special steels and other materials that have proven to best withstand the wear and stress subjected to each particular part and to assure the maximum of service and durability. Timken Taper Roller Bearings used throughout.



Main Frame Assembly

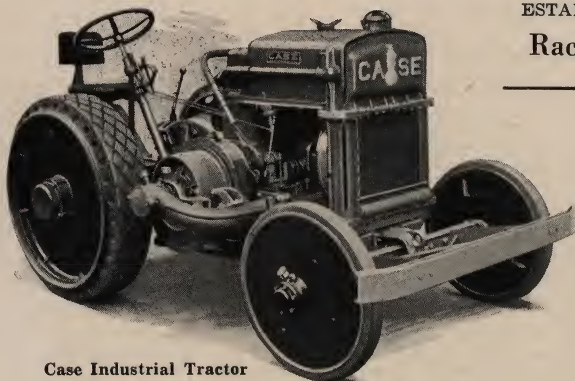


Driving Sprocket Discs Partly Removed

J. I. CASE THRESHING MACHINE COMPANY, INC.

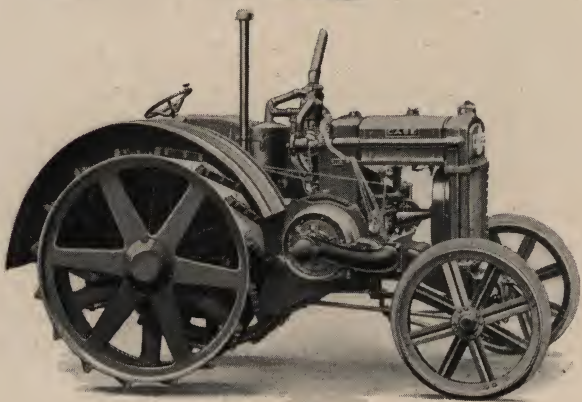
ESTABLISHED 1842

Racine, Wis.



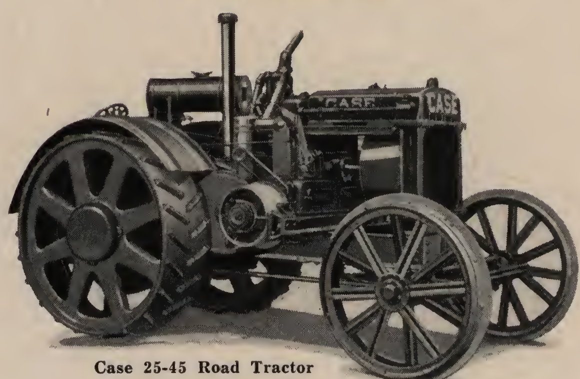
Case Industrial Tractor

Case Industrial Tractor: Here is a tractor developed and built to furnish industries and road engineers with exactly what is desired in an Industrial Tractor. It is unusually compact, having a 65" wheelbase, 61" width and 55½" height. The outside turning radius is only 10'. A worm gear steering device makes it handle easily without jerking out of control. It steers easily with or without a load. Rear wheels are fitted with 40x10" rubber tires and the front wheels with 27x3½" rubber tires. Approximately two-thirds of the tractor's weight is carried by the rear wheels, which gives them an excellent grip on ordinary surfaces. Rated at 12-20 H. P., it has ample reserve for big loads. There are two speeds forward of 4.23 M. P. H. and 3.06 M. P. H. and one in reverse.



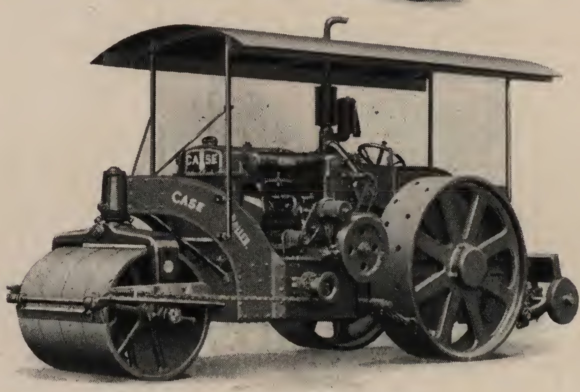
Case 18-32 Road Tractor

Case 18-32 Road Tractor: This Case tractor is notably economical in the use of fuel both on variable loads and on steady loads. The exhaust heated manifold completely vaporizes the fuel mixture. It is provided with positive force-feed lubrication. The three plain bearings prevent deflection of the crankshaft and insure its rigidity. All gears run in a bath of oil even to the worm steering gear. Oil proof housings surround the working parts to protect them from dust and to retain the lubricant. The rigid one-piece main frame will not twist. Such construction is highly desirable in tractors that are used for road building and other heavy work.



Case 25-45 Road Tractor

Case 25-45 Road Tractor: The Case 25-45 road tractor is especially well adapted to all kinds of heavy road work. It is very easy to handle because of the worm steering gear, convenience of controls and short turning circle. Its low center of gravity with ample clearance is important in road construction work. High grade materials replace massive heavy parts. The vertical four-cylinder valve-in-head engine of special Case design is economical in the use of fuel. It will burn kerosene and other low-grade fuels. High traction efficiency results from the simple spur gear transmission completely enclosed and running in oil. Belt pulley mounted on extension crankshaft delivers all of the engine power on the belt. The replaceable bearings, renewable wearing parts throughout, removable cylinder bearings, dependable air cleaner and pressure engine lubrication assure long life and lasting efficiency.



Case Ten-Ton Gas Road Roller

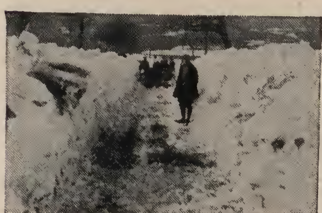
Case Ten-Ton Gas Road Roller and Scarifier: The method of mounting the Case gas road roller makes it unusually easy handling. It has a short turning circle, convenient controls, variable speed and an electric starter. The power is delivered from the engine to the drivers by completely enclosed spur gears running in oil. The result is high traction efficiency. The engine is a vertical four-cylinder valve-in-head Case designed product. Economy of operation is obtained by burning kerosene and other low-grade fuels as well as gasoline. Replaceable parts wherever they are subject to wear, a positive air cleaner and force-feed lubrication, together with the best materials and design, are responsible for the durability of this roller. The full roller width scarifier with variable depth cut is forced into the ground with four-ton air pressure. It is rigidly attached to the rear of the roller and is controlled by the roller operator.

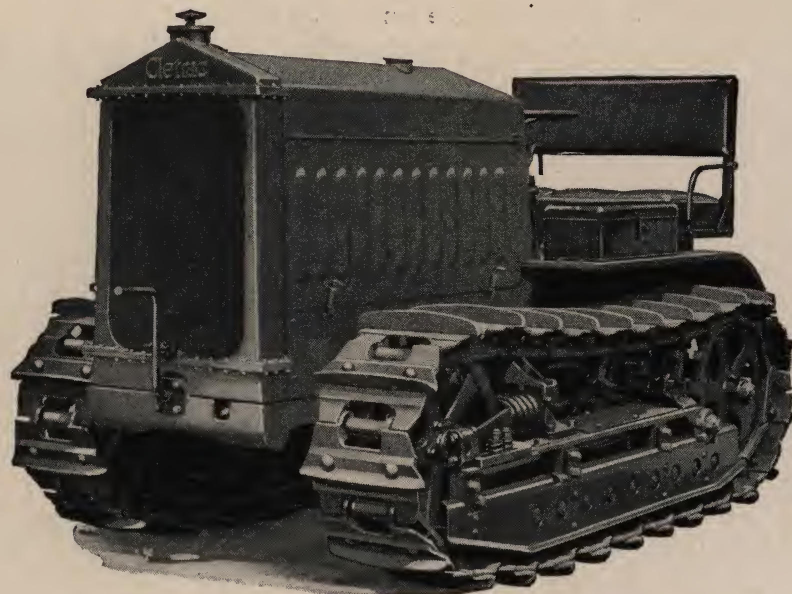
THE CLEVELAND TRACTOR CO.

19300 Euclid Ave., Cleveland, Ohio

Manufacturers of Cletrac Crawler Tractors

Products: CLETRAC CRAWLER TRACTORS.





Built in Four Sizes—Cletrac 20—Cletrac 30—Cletrac 40—Cletrac 100

The tractor that can do the greatest variety of work is the tractor that best serves engineering interests. That is why CLETRACS are chosen by so many road contractors, state highway departments, municipalities and counties. CLETRACS are designed to handle perfectly, not a limited number of jobs, but every type of work for which tractors can be employed. Road and street work, excavating, earth moving, hauling, snow clearing, land development—all these tasks are handled by a CLETRAC with utmost efficiency, speed and economy.

Road and Street Construction: The CLETRAC'S great power and ruggedness fit it for operating with the heaviest kinds of implements and tandem equipment. Its extensive use by road contractors and state highway departments is ample endorsement of exceptional ability for heavy-duty work. And as for economy, CLETRACS operate at **lowest cost per hour, per yard, per mile.**

City Development Work: In opening up and laying out new sub-divisions, putting in water mains and sewers, grading, earth moving, etc., CLETRACS are the ideal power units. They are on the job in any weather and operate efficiently in mud and other difficult going.

Snow Removal: No other power unit can approach the CLETRAC for winter operation. When drifts pile up—when streets and roads are closed by snow and ice—CLETRAC and a snow plow open up the highways, keep traffic moving, avert isolation of any community. Write for full details of the complete CLETRAC line. All models have the distinctive CLETRAC features of positive traction, unusual reserve power, "One-Shot" plunger-type oiling and automobile-like handling. Descriptive literature and list of municipalities and villages owning CLETRACS will be sent on request.

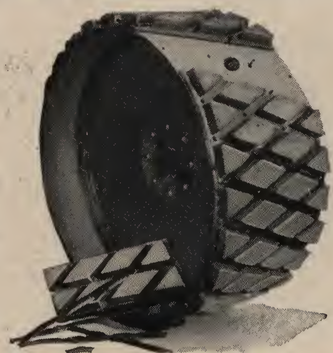
DURKEE-ATWOOD COMPANY

Minneapolis, Minn.

Manufacturers of Wheels and Rubber Tire Equipment for Tractors

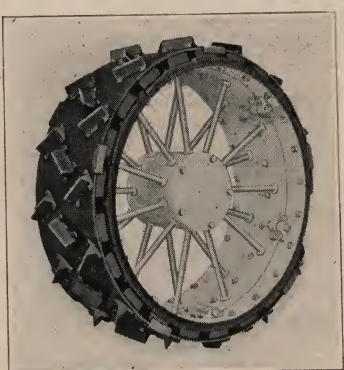
Products: THE NEW DURKEE-ATWOOD WHEELS AND RUBBER TIRE EQUIPMENT FOR ALL WHEEL TYPE TRACTORS AND SNOW GROUSERS FOR MOUNTING OVER SOLID TYPE TIRES.

Durkee-Atwood Barth Type Sectional Tires: The most economical traction for any wheel type tractor, with all the good features of the Barth tire improved, strengthened and redesigned to stand up under the hardest kinds of work. The new tire sections are securely fastened to the rim with new steel cross and side clamps of improved design, heavier and stronger and with fewer required.



Durkee-Atwood Sectional Tire on Fillable Type Wheel

The tire offers more in the way of surface support and traction. It enables the tractor to work over soft ground, packing the loose dirt rather than cutting into it. No ruts are left in the road for water to follow. The self-cleaning, diagonal grooves afford a positive grip on wet or dry surfaces.



Snow Grousers Mounted Over Durkee-Atwood Tire on French and Hecht Wheel

The greater road contact affords more tractive effort with less weight and maintains an even pull on the motor. This saving in power absorbed to move the tractor, is always available at the draw bar.

Durkee-Atwood wheels and Tire Equipment fill a gap between the ordinary solid tire and crawler equipment. They afford many of the desirable features of both, combining greater traction with rubber resiliency and wheel speed.

McCormick-Deering 15-30 with Durkee-Atwood Wheel Equipment

To remove or install a tread section, the only tool required is a wrench. One or all sections can be put on or taken off without removing the wheels from the tractor.

Many tractor units rejected with ordinary wheels have been approved when equipped with Durkee-Atwood wheels and tires.

Fordson Equipped with Durkee-Atwood 42x16 In. Wheels and Tires

Sizes: Durkee-Atwood wheels and tires are made in the following sizes for Industrial, 10-20, and 15-30 McCormick-Deering Tractors; also for Fordson Tractors:

Fordson with Loader Equipment and D.-A. 42x22 In. Wheels

Rear Wheels

For the 10-20 and Industrial Tractor		For the 15-30 Tractor	
Size	Weight per wheel	Size	Weight per wheel
42x16 in.	600 lbs.	50x16 in.	750 lbs.
42x22 in.	840 lbs.	50x22 in.	960 lbs.
46x16 in.	660 lbs.		
46x22 in.	865 lbs.		
Front Wheels			
28x 6 in.	300 lbs.	32x 6 in.	340 lbs.

Wheels for Fordson Tractors

Rear Wheels		Front Wheels	
Size	Weight per wheel	Size	Weight per wheel
42x12 in.	480 lbs.	24x6 in.	260 lbs.
42x16 in.	560 lbs.	28x6 in.	300 lbs.
42x22 in.	800 lbs.	32x6 in.	340 lbs.
46x12 in.	500 lbs.		
46x16 in.	620 lbs.		

Wheel diameters as listed are the over-all dimensions including the rubber tread.

The above rear wheel weights can be increased approximately 3½ times by filling with steel punchings.

Prices and Engineering Service: Complete information regarding sizes, prices and the application of our snow grousers given on request.

HERCULES MOTORS CORPORATION

Canton, Ohio, U. S. A.

Manufacturers of Internal Combustion Engines and Power Units

HERCULES DISTRIBUTORS

Beckwith Machinery Co., Pittsburgh, Pa.
Edward R. Bacon Co., San Francisco, Calif.
Fort Wayne Pipe & Supply Co., Fort Wayne, Ind.
General Machinery Co., Spokane, Wash.
Hardwicke-Etter Co., Sherman, Tex.
H. W. Moore Equipment Co., Denver, Colo.
Queen City Supply Co., Cincinnati, Ohio
Roy C. Whayne Supply Co., Louisville, Ky.
Sheehan & Company, El Paso, Tex.
Smith-Booth-Usher Co., Los Angeles, Calif.
Nickerson Machinery Co., Salt Lake City, Utah.
English Bros. Machinery Co., Kansas City, Mo.
Hudson Brick & Supply Co., Washington, D. C.
W. H. Hale & Co., Minneapolis, Minn.
John McNeilly Co., Columbus, Ohio
K. B. Noble Co., Hartford, Conn.
Yancey Bros., Atlanta, Ga.
Fallon & Schnelle, Inc., Little Rock, Ark.
Standard Salt and Cement Co., Duluth, Minn.
American Machinery & Supply Co., Omaha, Neb.
Anderson Sales & Distributing Co., Jackson, Miss.
Norvell-Wilder Hardware Co., Beaumont, Fort Worth and Houston, Tex.; Shreveport, La.
The Western Supply Co., Tulsa, Cromwell, Blackwell, Covington, Pearson and Seminole, Okla.; Borger, Texas

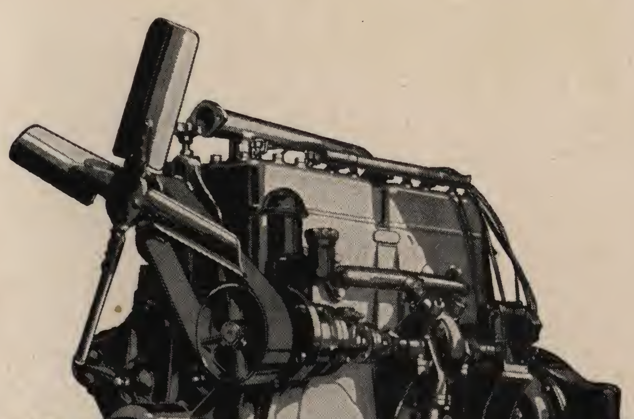
Products: HERCULES INTERNAL COMBUSTION ENGINES AND HERCULES POWER UNITS.

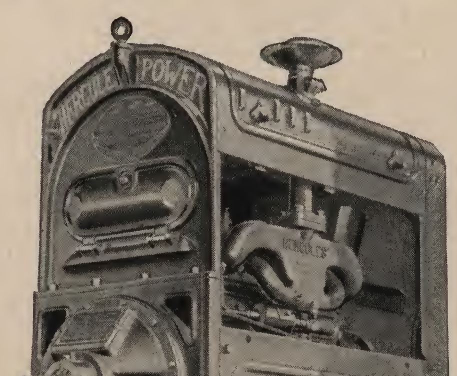
Hercules Power from 20 H. P. to 115 H. P. for every industrial requirement is available in the following sizes:

Four-Cylinder Engines		Six-Cylinder Engines		Power Units	
Model	Size	Model	Size	Model	Size
OX	4x5	WXA	3⅜x4½	OX	4x5
K	4¼x5¾	WXB	3¾x4½	K	4¼x5¾
L	4½x5¾	WXC	4x4½	L	4½x5¾
G	4¾x5¾	YXB	4x4¾	G	4¾x5¾
TX	5½x7	YXC	4⅜x4¾	TX	5½x7
TXA	6x7			TXA	6x7
TXO	6⅜x7			TXO	6⅜x7

Hercules Engines or Power Units are obtainable as standard equipment on the following machines:

Air Compressors
Asphalt Plants
Backfillers
Cane Mills
Centrifugal Pumps
Concrete Mixers
Conveyors
Cotton Gins
Cranes
Drag Lines
Diggers
Ditchers
Dredges
Dump Trucks
Electric Generators
Electric Light Plants
Electric Welders
Elevators
Excavators
Farm Tractors
Flour and Feed Mills
Gasoline Shovels
Gravel Plants
Harvesters
High Pressure Pumps
Hoists
Hydraulic Machinery
Industrial Tractors
Irrigation Pumps
Loaders
Locomotives
Logging Machinery
Marine Applications
Mining Machinery
Motor Coaches
Motor Trucks
Oil Field Equipment
Pavers
Pumps
Rail Cars
Refrigerating Machinery
Road Building Machinery
Road Maintenance Work
Road Rollers
Road Scrapers
Sand Cutters
Saw Mills
Scows
Shovels
Snow Plows
Spading Machines
Stand-by Equipment
Stone-Gravel Crushers
Street Sprinklers
Street Sweepers
Telephone Stations
Threshers
Track Layers
Trenchers
Turntables
Well Drillers (Oil-Water)
Winches
Wood Working Machinery





PERFEX CORPORATION

FORMERLY RACINE RADIATOR CO., RACINE, WIS.

Milwaukee, Wisconsin

Makers of Perfex Bronze-Core Radiators for Dependable Industrial Machines

Pacific Coast Representative: ENGINEERING AND SALES COMPANY, 555 Howard St., San Francisco, California.

Products: PERFEX BRONZE-CORE RADIATORS.

RADIATORS FOR COOLING MOTORS OF ALL KINDS OF GAS OR OIL POWERED MACHINES.

PERFEX

THE PERFECT RADIATOR

Sheet Metal Tank Type. Tanks of heavy gauge sheet metal thoroughly reinforced at suspension and connection points. Used extensively on many types of industrial machines where saving of weight is an important factor.

Cast Tank Type. For trucks, industrial machinery and general heavy duty service. Tanks of fine, non-porous gray iron of motor-casting quality. Walls thin for light weight. Mounting lugs, flanges and connections heavy for great strength. Castings accurately ground or milled.

Sectional Core Type. Has same tanks as cast tank; but with core made in removable sections. Usually used where machines are exposed to unusually severe conditions. Additional protection given by heavy bars.

When choosing an unfamiliar product it is well to follow the leaders in the industry that use it. At the 1928 Cleveland Good Roads Show, 86 per cent of the exhibitors of gas-driven industrial machinery were using PERFEX Radiators.

They were divided as follows: On Power Units, 12 out of 14; Air Compressors, 9 out of 13; Concrete mixers, 18 out of 19; Power Shovels and Cranes, 23 out of 28. Name the jobs that are Perfex-cooled and you name recognized leaders. Right straight down the line, you will find Perfex Bronze-Core Radiators on practically all the high-grade equipment.

What's the answer for this overwhelming preference for Perfex Radiators? Thoroughly satisfactory performance over a period of years.

We publish this statement to show that we hold our present customers and seek new ones on just one basis—furnishing the best radiator that can be built.

Perfex the Perfect Radiator: You may or may not be interested in details of radiator design, but certainly you are vitally concerned with performance of your equipment. Note, therefore, that over 100 of America's foremost engineers have chosen Perfex Radiators as standard equipment.

When you buy new power equipment, get it with a Perfex Radiator. In every line of gas or oil-powered equipment, there's at least one that's Perfex-cooled—often several. You'll find they're the machines with long records of success, the kind that give satisfactory, low-cost service. So see that your new machines are Perfex equipped and you will never be shut down on account of cooling trouble.

Perfex Cores: The core material is a special analysis bronze of greater tensile strength than either brass or copper. It is not affected by chemicals or alkali found in water.

Three Types Built: Sheet metal tank types are used on industrial machines where weight saving is important. Cast iron tank types are used for heavy duty service on truck and industrial machinery, where strength and not weight is a factor. Sectional Core types have removable sections and are used where machines are exposed to severe use. Protecting bars are standard equipment on them.

HYATT ROLLER BEARING COMPANY

Newark, N. J.

Roller Bearings for Road Building Equipment

Branch Offices: Detroit, Chicago, Pittsburgh, Oakland

HYATT
ROLLER BEARINGS
PRODUCT OF GENERAL MOTORS

Products: ROLLER BEARINGS FOR ROAD BUILDING EQUIPMENT.

Features and Advantages: When buying, recommending, or constructing road building equipment the advantages to be gained by the use of Hyatt Roller Bearings should be considered.

These bearings offer the following features.

1. The easily rotating action of steel rollers at bearing points in place of the rubbing friction of plain bearings.

2. Positive oil-conserving lubrication due to the distinctive construction of the alternately assembled right and left hand helically wound rollers, together with the advantages of oil tight housing.

3. Rugged strength, resulting from highest grade steel, correct design and good workmanship.

In all classes and types of equipment these features insure profit-increasing operating advantages. Some of these are as follows.

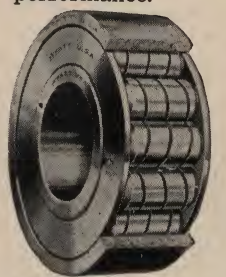
1. **Time Saving.** Easier starting and faster operation, resulting in continued gains in speed and earlier completion of work. No time is required for bearing adjustments or replacements. Oiling is required only three or four times a year.

2. **Operating Economies.** Substantial saving of fuel due to easier running and greatly reduced friction losses. Saving of oil through reduced lubrication requirements. Labor saving resulting from easier operation, elimination of maintenance troubles and infrequent oiling.

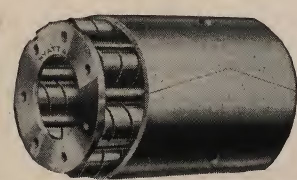
3. **Dependability.** Assurance that work can be completed without trouble or holdups from bearing failures.

4. **Long Life.** Bearing durability insures longer life for the entire equipment. Destructive wear is prevented and wheels and shafts are held in true alignment.

Hyatt bearing equipment has inbuilt quality and stamina that is a guaranty of reliable and money-saving performance.



Solid Inner and Outer Race Type Bearing for Heavy Duty Machinery.



Split Race Type Bearing for Wheels and General Use.

THESE MANUFACTURERS ARE PREPARED TO FURNISH HYATT ROLLER BEARING EQUIPMENT:

Batch Box Cars
- Biehl Iron Works, Reading, Pa.
- Easton Car & Construction Co., Easton, Pa.
- Koppel Industrial Car & Equip. Co., Koppel, Pa.
- Lakewood Engineering Company, Cleveland, O.
- Light Railway Equipment Co., Philadelphia, Pa.

Concrete Block Cars
- H. D. Conkey & Company, Mendota, Ill.

Concrete Mixers and Pavers
- American Cement Machine Co., Keokuk, Ia.
- Besser Mfg. Co., Alpena, Mich.
- Blystone Mfg. Co., Cambridge Springs, Pa.
- H. Brewer & Co., Tecumseh, Mich.
- Chain Belt Co., Milwaukee, Wis.
- Norris K. Davis, San Francisco, Calif.
- Grey Iron Foundry & Machine Co., Reading, Pa.
- Lakewood Engineering Co., Cleveland, O.
- Lansing Co., Lansing, Mich.
- Ohio Concrete Machine Co., Columbus, O.
- Ransome Concrete Machinery Co., Dunellen, N. J.
- T. L. Smith Co., Milwaukee, Wis.

Contractor Wagons
- Western Wheeled Scraper Company, Aurora, Ill.

Drag Scrapers, Back Fillers and Trench Machines
- Austin Machinery Corporation, Muskegon, Mich.
- Monighan Machine Company, Chicago, Ill.

Excavators
- Bay City Dredge Co., Bay City, Mich.
- Insley Manufacturing Company, Indianapolis, Ind.
- Northwest Engineering Company, Green Bay, Wis.

Fordson-Crawler Attachments
- Bates Machine & Tractor Company, Joliet, Ill.
- Full-Crawler Co., Milwaukee, Wis.
- Moon Truck Company, Fullerton, Calif.
- Moore & Moore, Inc., Reading, Pa.
- W. A. Riddell Co., Bucyrus, O.

Gasoline Locomotives
- Atlas Car & Manufacturing Co., Cleveland, O.
- Bloomsburg Locomotive Works, Bloomsburg, Pa.
- Davenport Locomotive Works, Davenport, Ia.
- Fate-Root-Heath Company, Plymouth, O.
- Industrial Equipment Company, Minster, O.
- Mid-West Locomotive Works, Cincinnati, O.
- Milwaukee Locomotive Company, Milwaukee, Wis.
- Vulcan Iron Works, Wilkes-Barre, Pa.
- George D. Whitcomb Company, Rochelle, Ill.

Locomotive Cranes
- Ohio Loco Crane Co., Bucyrus, O.

Power Take-Offs for Truck Hoists
- Hydro Hoist Company, Milwaukee, Wis.
- Miami Scraper Trailer Co., Troy, O.

Pumps
- Domestic Engine & Pump Co., Shippensburg, Pa.

Road Building Tractors
- Allis Chalmers Company, Milwaukee, Wis.
- Avery Power Machinery Company, Peoria, Ill.
- A. D. Baker Co., Swanton, O.
- Bates Machine & Tractor Company, Joliet, Ill.
- Caterpillar Tractor Co., San Leandro, Cal., and Peoria, Ill.
- J. I. Case Threshing Machine Co., Racine, Wis.
- Cleveland Tractor Co., Cleveland, O.
- John Deere & Co., Waterloo, Ia.
- Eagle Manufacturing Company, Appleton, Wis.
- Electric Wheel Company, Quincy, Ill.
- Emerson-Brantingham Co., Rockford, Ill.
- Frick Company, Waynesboro, Pa.
- Gray Tractor Co., Minneapolis, Minn.
- Hart Parr Company, Charles City, Ia.
- Huber Manufacturing Company, Marion, O.
- International Harvester Co., Chicago, Ill.
- John Lauson Mfg. Company, New Holstein, Wis.
- Minneapolis Steel & Machinery Co., Minneapolis, Minn.
- Minneapolis Threshing Machine Co., Hopkins, Minn.
- Monarch Tractors, Inc., Watertown, Wis.
- Moore & Moore, Inc., Reading, Pa.
- Rock Island Plow Company, Rock Island, Ill.
- Shaw Enochs Tractor Co., Minneapolis, Minn.
- Yuba Manufacturing Company, Benicia, Calif.

Road Graders
- J. D. Adams & Company, Indianapolis, Ind.
- Acme Road Machinery Company, Frankfort, N. Y.
- American Road Machinery Co., Kennett Square, Pa.
- Galion Iron Works, Galion, O.
- Shaw-Elcox Company, Minneapolis, Minn.
- Stockland Road Machinery Company, Minneapolis, Minn.
- Wehr Company, Milwaukee, Wis.

Road Rollers
- Acme Road Machinery Company, Frankfort, N. Y.
- Buffalo-Springfield Company, Springfield, O.
- Erie Machine Shops, Erie, Pa.
- Galion Iron Works, Galion, O.
- Huber Manufacturing Company, Marion, O.

Steam Shovels
- Marion Steam Shovel Co., Marion, O.
- Ohio Power Shovel Co., Lima, O.

Sweepers, Snow Plows and Snow Loaders
- Butler Mfg. Co., Kansas City, Mo.
- Russell Car & Snow Plow Company, Ridgway, Pa.
- Harrisburg Boiler & Mfg. Co., Harrisburg, Pa.

Tar Wagons
- Connery & Company, Philadelphia, Pa.
- Littleford Bros., Cincinnati, O.
- Union Iron Works, Hoboken, N. J.

Trailers
- La Plant Choate Mfg. Co., Cedar Rapids, Iowa.

THE CONNEAUT SHOVEL COMPANY

Conneaut, Ohio, U. S. A.

Manufacturers of Shovels, Scoops, Spades and Kindred Products

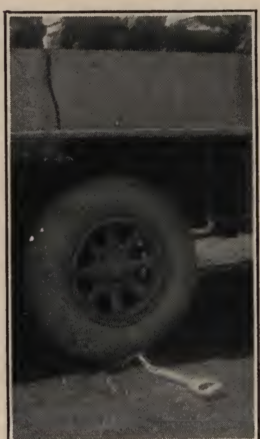
BRANCHES IN PRINCIPAL CITIES

Products: Shovels, Scoops, Spades, Drain and Ditching Tools, Telephone Shovels and Spoons, Snow Scrapers, Ice Choppers and Kindred Articles.

Also Second Growth Northern Ohio White Ash Handles.

Conneaut Special Shovels: appears on the ferrules of Conneaut Special Shovels. This means "Heat Treated" as well as a shovel that is superior in every way to the ordinary shovel.

We manufacture Conneaut Special Shovels from a special analysis steel heat treated by our own secret process.



You can drive over the shovel with a very heavy truck without damaging it.

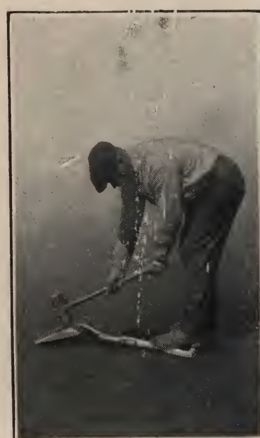
Our handles are made in our own plant of the very best Second Growth Northern Ohio White Ash obtainable and are thoroughly air seasoned by Nature's own process before using.

A special shovel is one which exactly "fits the job" for which it is intended—one that will move most material in a given time with the least possible exertion.

That is the kind which The Conneaut Shovel Company makes.

Some employers only discover the advantages of Conneaut Special Shovels by accident, just as one contractor discovered that our No. 4 Diamond Point Shovel would handle more crushed rock per day than any other shovel he had ever used.

It isn't necessary for you to experiment. Our shovel specialists can supply you with a Conneaut Special Shovel for your work—specially designed, specially forged and tempered from special analysis steel, and specially balanced so as to enable the man who uses it to perform more work without knowing it.



You can pound the back of the shovel with a heavy maul

Round Nose Gravel Scoop—Excellent for digging into loose materials

Long Handle Excavating Shovel—Does the work of both pick and shovel—plain back, round point, 4½ ft. handle, 30-34 in. drop

Dirt and Railroad Tamping Shovel—A good general purpose shovel—built to stand abuse

Only a Few of the Many Styles of Shovels Which We Manufacture

WESTERN CRUCIBLE STEEL CASTING CO.

2833 Grand Avenue, Minneapolis, Minn.

Manufacturers of Westeeco Dipper Teeth, Bases and Westeeco Products

Products: DIPPER TEETH AND BASES FOR GAS AND STEAM SHOVELS.

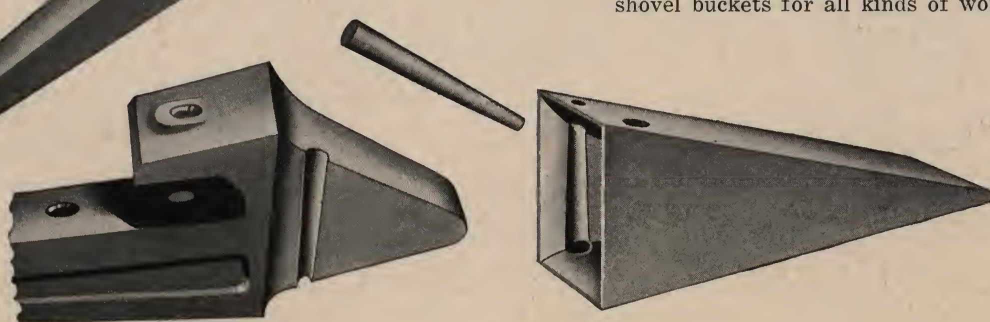
Westeeco Dipper Teeth combine two features—simplicity of design—and exceptional durability, to make them the most desirable dipper teeth for steam shovel operators to use.

Westeeco Teeth are simple—just three parts—base—tooth and pin—the tooth is the box type, slipping snug over the base and held secure by a pin, thus making it easy for two men to make changes or reverse a complete set of teeth on even the largest buckets in just a few minutes—a two and one-half yard bucket can be changed by one man in five minutes.

Made of WESTEECO STEEL—an alloyed steel—the result of an exhaustive investigation in the steam shovel field by our metallurgical department. Westeeco Steel possesses the ability to withstand greater shock and abrasive wear and gives to Westeeco Teeth a durability that is far beyond that of old style dipper teeth.

Chert—Shale—Sandstone—Rock or iron ore—all are dug with equal ease by Westeeco Teeth.

Forgeable too—simply draw out the points on Westeeco Teeth when they finally seem to be worn out—and they are again good for thousands of yards of heavy digging.



In ordering or inquiring about teeth, we would require that you send us a rough sketch showing the thickness of the lip, the dimensions of the holes and distance between them. Also advise whether or not the bases are attached on the inside of bucket or the outside. We would also request you give us the name or make of bucket, model of machine, the number of bases required and the size of the bucket.

A Few Operators Say: "Working in rock, the minimum number of hours your teeth worked was 117, while other teeth working the same material had to be changed at the end of six hours. They certainly are satisfactory."

"For about a year we have been using your Westeeco Dipper Teeth on our dragline buckets, and have found them entirely satisfactory. We feel that you have perfected a tooth that is of great advantage to dragline operation."

"The method of fastening the points—which gives a quick and easy method for reversibility—results in longer wear. We recommend their trial by any concern using teeth on steam shovel buckets for all kinds of work."

Westeeco Products Include Caterpillar Tractor Parts: We manufacture a complete line of track parts for five and ten ton Artillery Type Tractors such as track-links, spacers, pins, roller-brackets, rollers, truck wheels, gudgeons, sprockets, and ice and snow grousers. Made of special grade of Westeeco Metal.

RAWLS MANUFACTURING COMPANY

SUCCESSORS TO RAWLS MACHINE & MANUFACTURING WORKS

202-210 Iowa Ave., Streator, Ill.

Manufacturers of High Speed Heavy Duty Steel Highway and Railway Mowing Equipment

Products: Highway and Railway Mowing Equipment.

Rawls Heavy Duty Mower is designed **solely** for highway mowing and can in no way be compared with the ordinary mower. It operates approximately four times as fast, cuts all angles from straight up to straight down and demounts automatically when obstruction is met.

The Rawls Mower is not a one man mower, as one man cannot properly operate mower at 6 to 8 miles per hour and give mower proper attention against the heavy traffic of today. Two men, one properly operating the Rawls Mower only, the other driving the towing unit can maintain speed of 6 to 8 miles per hour, giving due consideration to traffic and proper care of equipment and will cut more vegetation than 3 or 4 one man units.

Records indicate that 2 men or more on any mechanical device greatly eliminates hazards with more economical and efficient performance on highways with the heavy traffic of today, also that the best is always the cheapest in the end.

With the keen competition that is prevalent among communities, first impressions are all-important. Nothing will give the tourist or the passer-by a better impression of a community than a clean, well-trimmed highway or street.

A weedy highway is a constant source of danger to the neighboring fields. The weed seeds ripen and are spread broadcast by the winds.

The collection of dirt, trash, and vegetation holds moisture and prevents proper drainage by clogging the ditches and drains, and gradually softens and damages the road bed. Frequent use of a highway mower keeps the vegetation down, and gives the sun a chance to dry the road bed, and lessens the problem of snowdrifts in winter by lessening the wind resistance.

Power—Mowing Unit Towed with automobile, truck, tractor or any source of power greater or equivalent to Ford roadster.

Construction: Every part is designed for maximum efficiency and constructed of high grade, wear-resisting material, to assure long, trouble-proof and economical service.

The Rawls Highway Mower is built of heavy metal construction throughout, and all moving parts are carefully assembled and protected from damage and excess wear.

There is nothing to get out of order and few parts that need replacement, on the chassis. The cutter bars are designed to give the maximum cutting service with the minimum of attention.

All parts are guaranteed against defective workmanship or material.

Continued on Next Page

State Highway Departments Using Rawls Heavy Duty Highway Mowers:

Arkansas	Maryland	South Carolina
Florida	Michigan	Virginia
Georgia	Missouri	Washington
Idaho	North Carolina	Wyoming
Indiana	Oregon	California
Louisiana		

County and City Highway Departments Using Rawls Heavy Duty Highway Mowers:

Orange County, Orlando, Florida
Apalachicola, Florida
Minidoka County, Rupert, Idaho
Kane County, Geneva, Illinois
Tippecanoe County, Lafayette, Indiana
Sumner County, Wellington, Kansas
Bourbon County, Fort Scott, Kansas
Gogebic County, Bessemer, Michigan
Marquette County Ishpeming, Michigan
Gratiot County, Ithaca, Michigan
Chippewa County, Sault Ste. Marie, Michigan
Tuscola County, Caro, Michigan
Alger County, Munising, Michigan
Hennepin County, Hopkins, Minnesota
Ozaukee County, Port Washington, Wisconsin
Trempealeau County, Arcadia, Wisconsin
Walworth County, Elkhorn, Wisconsin

Tires: Front wheels, solid rubber, 3 in. wide, 2 in. thick, 16 in. diameter, moulded in iron rim, and pressed on rim of wheel. Rear wheels, solid rubber, 3 in. wide, 2 in. thick, 24 in. diameter, moulded in iron rim and pressed on rim of wheel.

Shafting: Chrome Nickel and cold rolled steel in mower parts.

Castings: Electric steel (except A6, which is machine cut semi-steel.)

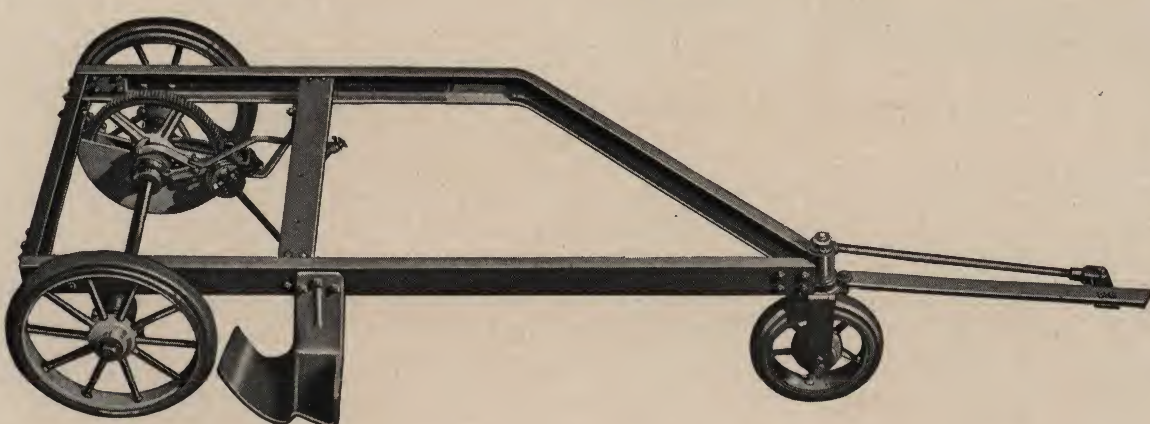
Cutter Bar: 5, 6, or 7 ft. long.

Weight: 1,200 lbs., complete.

Speed: 6 to 8 miles per hour while mowing, 15 to 20 miles per hour when mower is not in operation.

Announcement: We are announcing the Type "J" Rawls Mower. This Mower weighs approximately 175 lbs., having 3-ft. cutter bar, with gasoline propelled sickles and traction. The low price we will announce on this machine will be surprising.

Each machine is equipped with steel tool box 6"x6"x18" with clasp for lock; bolted to floor on left side of chassis. The following extra parts are furnished with each machine:



SPECIFICATIONS

Frame: 4 in. channel steel, 6 ft. long, 41¼ in. wide.

Floor: 2 in. thick, 6 ft. long, 42½ in. wide.

Axles: Rear, 1½ in. steel, finished to 1 7/16 in., keyed to wheels. Front, 1 7/16 in. finished steel.

Bearings: Hyatt roller bearings in front wheel and in rear boxes.

Bushings: Manganese bronze, fitted to all movable shafts in mower.

Wheels: Rear, steel, keyed to axle, 24 in. rubber tires. Front, steel, straight hub, for 16 in. rubber tires.

1 Extra sickle bar, complete.
2 Universal tee pins (10B).
8 Universal ring rivets (11A).
1 Drive wheel key (38A).
1 Pinion shaft key (8B).
2 Sickle sections (44).
1 Guard (42).
1 Oil can (68).
1 Guard bolt (42A).
1 Guard bolt (42B).
1 Wrench (35F).
1 Adjustment washer, ⅞" I.D. (37A).
1 Adjustment washer, 1⅛" I.D. (37D).
¼ lb. Sickle head rivets (33A).
¼ lb. Sickle section rivets (44A).

Guarantee: All parts are guaranteed against defective workmanship or material.

Deliveries and Prices of Highway Mower, complete with chassis and information concerning delivery gladly furnished on request.

THE AMERICAN METAL HOSE COMPANY

Waterbury, Conn., U. S. A.

Manufacturers of Flexible Metal Hose and Tubing

SALES OFFICES

New York, N. Y., 173 Lafayette St. **Boston, Mass.,** 201 Devonshire St.
Chicago, Ill., 111 West Washington St. **Pittsburgh, Pa.,** 1820 Oliver Bldg.
Canadian Selling Agent, Lytle Engineering Specialties, Ltd., Montreal, Canada.
Pacific Coast Agent, F. Somers Peterson Co., San Francisco, Calif.

Products: AMERICAN FLEXIBLE METAL HOSE AND COUPLINGS.

Uses: American Flexible Metal Hose is applicable to almost every service requiring a flexible hose, tubing, conduit or casing. Its efficiency and economy are most pronounced, however, where high pressures, rough handling or chemical action limit the life of other types of hose. The conveying of oils, grease, tar, asphalt, creosote, steam, water, air, gas, paints, varnish, dust, shavings, chips, filings, etc., are some of the many services for which American Flexible Metal Hose is particularly adapted.

American Flexible Galvanized Steel Tank Car Unloading Hose.—Unloading Hose is supplied in four sizes only—2, 2½, 3 and 4 inch. An Unloading Hose Assembly consists primarily of a length of BD 15 Interlocked Galvanized Steel Hose. To the end of the hose

Unloading Easily, Quickly and Efficiently with an "American" Unloading Hose Assembly.

which is to be connected with the storage tank line an iron pipe thread swivel female coupling is attached. Depending on the temperature of the material unloaded the coupling is either a packed-on, heat-proof coupling or one attached with solder. On the end of the hose which is to be connected to the Tank Car outlet a 45° Elbow Coupling threaded (5¼ in. by 4 threads per inch) to fit the standard outlets of Tank Cars is attached. In case the material is to be unloaded at low temperatures the Elbow Coupling is soldered direct to the Hose. If it is unloaded at temperatures high enough to melt solder (350° to 375° Fahrenheit) a packed-on, heat-proof swivel female coupling is first attached to the hose and a 45° Elbow Coupling having its shank threaded male iron pipe thread is screwed into it. The advantage of using an Elbow Coupling instead of a Straight Coupling to connect with the Tank Car Outlet

BD 15 Hose.

is well demonstrated by the fact that the 45° Elbow Coupling allows the Hose to fall away from the outlet in an easy, natural curve, whereas if a straight coupling were used there would be a sharp bend with a consequent severe strain on the hose where it bent away from the coupling. Occasionally a Tank Car Outlet is threaded iron pipe thread. In such a case connection is made by means of a special Brass Reducing Bushing. This Bushing carries a female iron pipe thread which screws onto the Tank Car outlet and a special 5¼ in. by 4 threads per inch male thread over which the Elbow Coupling is screwed. The extreme flexibility of American Galvanized Steel Unloading Hose allows connections to be made quickly and easily, eliminates "spotting" the car, and reduces the "spillage" to a minimum. It is unaffected by oils, tar, asphalt, etc., and gives long and efficient service when used for unloading Tank Cars of these materials.

American Flexible Bronze Steam Hose.—BD 15 (Unbraided) is manufactured in standard sizes from 3/16 in. up to 8 in. diameter, and BD 20 (Braided) in sizes from 3/16 in. to 1¼ in. inclusive, and usually is equipped with packed-on, heat-proof Couplings having an iron pipe thread corresponding to the inside diameter of the Hose. In general BD 15 (Unbraided) Bronze Hose is recommended for

Set of Soldered Couplings.

conveying steam or corrosive materials at normal pressures and under normal service conditions. Where the Hose is used at high pressures or is subjected to continual bending or handling BD 20 (Braided) Bronze Hose should be used. In the smaller sizes under ½ in. in diameter BD 20 or Braided Hose is the logical Hose in almost every instance, as the braid acts as an added support, prevents twisting and lessens the chances of bending the Tubing beyond its natural bending radius. In sizes over 1¼ in. in diameter a braid is not supplied, as it is unnecessary in view of the strength of the heavy metal used in the larger sizes of Flexible Metal Hose. The packed-on, heat-proof, couplings which are attached to Steam Hose are specified either as Number 1 or Number 2 Packed Couplings. The Number 1 Packed Couplings have no reinforcements and should be used on Hose for normal services. Number 2 Packed Couplings are equipped with flexible metal reinforcements and should be used on Hose for strenuous services. Flexible Bronze Steam Hose is unaffected by steam at high or low pressures, always retains its flexibility, is light but at the same time strong, and does not deteriorate when not in use. It is used for all sorts of flexible steam connections but is especially adapted to blowing out boiler flues and steaming out Tank Cars.

American Flexible Galvanized Steel Oil Hose.—BD 15 (Unbraided) Steel Oil Hose is also manufactured in standard sizes from 3/16 in. up to 8 in., and BD 20 (Braided) from 3/16 in. to 1¼ in. inclusive, and is usually equipped with soldered-on iron pipe thread couplings. In deciding whether BD 15 or BD 20 Steel Oil Hose is the proper type to use, follow the same rules as are employed in the choice of BD 15 or BD 20 Bronze Steam Hose. Soldered Couplings can be furnished either with or without flexible metal reinforcements. Flexible Galvanized Steel Oil Hose is used, because of its ability to

BD 20 Hose.

handle these materials without deterioration, for conveying oils, grease, tar, asphalt, creosote, cutting compounds, etc. In sizes between 1 in. and 2 in. it is used on the sprayers of road oilers and as "patching" hose and in many cases a length or two is carried as standard equipment for loading or unloading oilers or tar wagons.

Facilities.—Modern equipment, excellent shipping facilities, and complete stocks insure prompt shipments. The benefit of eighteen years of experience in the manufacture of Flexible Metal Hose is always at the disposal of users or prospective users of that material.

Fences for Preventing Snow Drifting

The first requisite for successful and economical snow removal is adequate drift prevention. By adequate drift prevention is meant sufficient protection to enable the plows to handle the work easily and to permit the use of light instead of heavy equipment on patrol. A few hundred feet of snow fence placed at strategic points many times save the use of a heavy outfit at points miles from headquarters. The portable or picket type of snow fence, made up with pickets woven between strands of wire is now quite widely used for drift prevention.

The following specification on snow fencing was taken from the Iowa standards:

Slat Snow Fencings.—Slat snow fencings shall consist of ½"x1½"x4' wood slats woven together with 5 cables—each cable consisting of two No. 12½ (American Steel and Wire gage) galvanized wires. The slats shall be spaced two (2) inches apart and shall be made of any durable wood except cottonwood or elm. The slats shall be painted or treated with creosote. The fencing shall be put up in rolls of from fifty (50) feet to one hundred (100) feet as specified by the county.

Showing Portable Picket Snow Fence

Drift is shown ahead of fence, which was placed fifty feet from the highway right-of-way line. The road was kept clear for traffic by use of light patrol snow removal equipment.

A picket fence with pickets close together and put up in 50 ft. to 100 ft. lengths is now used as a portable snow fence. This fence may be fastened to posts driven into the ground, 1½ in. hollow iron posts, or 3 in. to 4 in. or 1¾ in. x 1¾ in. x 3/16 in. x 6 ft. long, angle iron posts sometimes used for this purpose. In the spring these posts can be easily pulled when the ground is soft. A type of slat fence is shown in the illustration.

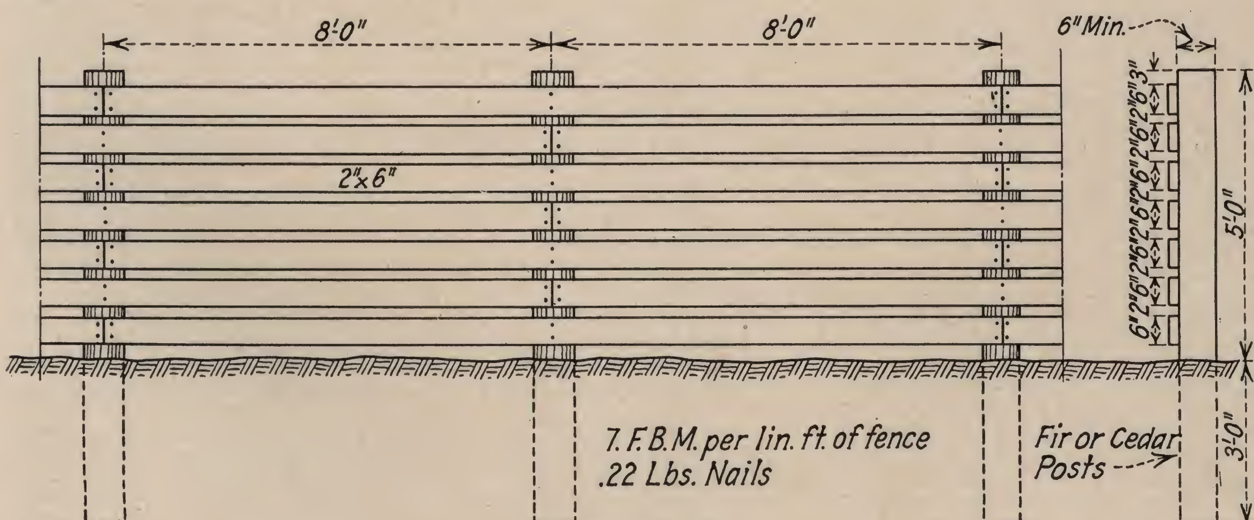
A stationary snow fence may be constructed by spacing 6 in. boards 2 or 3 in. apart on posts set vertically in the ground to a height of about 6 ft. above the surface.

The proper location for a snow fence, of course, is some distance back from the edge of the highway. This distance will vary according to the height of the fence. In general the distance from the edge of the road may be 8 to 10 ft. per foot of height of the fence.

J. C. McLean gives the following in *Engineering and Contracting*, regarding a portable slat fence placed last fall on three paved highways leading from Sioux City, Ia. The fence consisted of wooden pickets ½-in.x1½-in.x4 ft., woven between 5 strands of No. 12 wire, spaced 2 in. apart, painted with red mineral preservative, put up in rolls of 100 lin. ft. weighing approximately 360 lb. The fence was erected at distances varying from 35 to 60 feet back of the right of way line depending upon topographic conditions. A substantial wooden post was set in at both ends of each installation securely braced, with intermediate steel T-beam posts spaced 10 ft. centers in between, to which the fence was attached. A total of 15,000 lin. ft. was erected, the cost being as follows:

	Per Lin. Ft.
Fence	$0.069
Posts	.038
Hauling and labor in erection	.028
Total	$0.135

The posts with steel anchors cost from 31 cts. to 37 cts. each.



Permanent Snow Fence
Standard Wyoming State Highway Department

Snow Removal

General Methods

The Bureau of Public Roads of the U. S. Department of Agriculture has been making studies of snow removal methods and costs. The following abstracts were taken from a report on the subject by Mr. H. G. McKelvey of the Division of Construction:

Snow removal work was practiced more effectively and extensively by the State highway departments during the winter of 1926-27 than in any preceding year. As may be seen from Table I the mileage cleared on the State highway systems in the 36 States in the heavy snowfall area (over 20 inches annually) increased by 50 per cent each year until the winter of 1926-27. At that time the increase dropped to 15 per cent, indicating that the departments had extended their operations to practically all the principal roads on the systems and that henceforth the added mileage would be only the normal increase due to the gradual development of traffic. During the coming season the mileage that will be included in the program (estimated at 117,109 miles) is only 10 per cent above the mileage of last winter's program. A further study of Table I shows that during the four-year period beginning with 1922-23 the State highway departments have quadrupled the mileage of their snow removal operations and the total expenditures during the same interval have increased six-fold. The average cost of snow removal per mile of road has increased 55 per cent as a result of the public demand for more complete clearing, and unobstructed winter travel. The small increase in the average cost per mile for 1926-27 as compared with 1925-26—$43.50 against $40.38—probably indicates the approach toward a satisfactory standard of service.

In the winter of 1922-23 there were only 184 truck plows and 221 tractor plows in operation in the entire 36 snow States. In the next three-year period the total truck and tractor plows increased eightfold; the increase during the next year then dropped to 16 per cent. This would indicate that equipment to take care of the large mileage of roads was purchased as rapidly as funds were available until such a time as the main traveled roads of the State systems were brought under effective control by the snow removal forces.

TABLE I

The Increase in the Snow Removal Mileages and Expenditures in the 36 Heavy Snowfall States Over a Four-Year Period Beginning with the Winter of 1922-23

Winter	Total Roads with Snow Removed, Miles	Increase Over Preceding Year, Per Cent	Total Cost of Snow Removal	Increase Over Preceding Year, Per Cent	Average Cost Per Mile
1922-23	27,096	....	$ 762,159	....	$28.12
1923-24	41,302	52	946,262	24	22.91
1924-25	62,167	50	1,826,813	93	29.39
1925-26	93,006	50	3,757,663	106	40.38
1926-27	106,721	15	4,641,037	24	43.50
1927-28	117,109*	10	....	....	....

*Estimated.

The general demand seems to be for fast moving units, continuously operated during snowfalls, to keep the roads open to traffic at all times. The existing policy is a decided advance over the original procedure when it was considered necessary only to begin snow removal after the storm had passed, thereby causing a considerable loss to transportation agencies temporarily blockaded while the snow was falling.

Snow Removal Organizations Have Reached High State of Development.—The snow removal organization of one of the New England State Highway Departments is typical of the highly developed organizations which have been perfected in a number of the States during the past few years. The snow removal work in this State is controlled by eleven district supervisors under a superintendent of maintenance. Each district organization is composed of the necessary foremen, men, and equipment. The highly efficient personnel has been instructed to begin snow removal as soon as the roads have become covered to a depth of two inches. This amount of snow starts the organization to work automatically, without any further instructions from headquarters. The men assemble, according to a predetermined plan, at the various storage sites of the equipment; and if any fail to report for duty on time, it means the loss of their position with the highway department, unless they are able to give a reasonable excuse for their absence.

The equipment consists of 183 trucks, of various models and makes, scattered over the State at strategic points. These trucks are equipped with straight-blade plows. The State also has 7 V-plows operated by tractors. The straight-blade plows are used for light work and the heavy V-plows for the removal of drifted snow.

The location of each outfit is recorded, with large flat-headed pins, on a State map hung on the wall of the headquarters office. On each pin there is a number which indicates the make, power and condition of the truck, and the description of the plow attachment. The equipment allotted to the various districts is intended to be adequate for normal conditions, but it often happens that a heavy snowfall, which exceeds the capacity of the equipment, occurs in one district, while the surrounding regions are affected by little or no snowfall. In this case the personnel of the snow free districts are directed by the superintendent to proceed to the assistance of the crews in the heavy snowfall area. This help is not delayed until the overtaxed district is snowed in, but careful watch is maintained by the headquarters office, and the relief units from the surrounding districts are hurried to the scene before the local crews have lost control of the situation. As the various units are moved to their new temporary locations, the pins on the headquarters map are shifted accordingly.

Equipment.—With the exception of such progressive improvements in snow plows as might be expected, this type of equipment remains essentially the same as formerly reported. Those engaged in the work appear to be giving their attention chiefly to the motive power employed, in order that wider roads may be opened and maintained with the greatest possible speed. The mold-board snow plow, the lighter and heavier types of V-plows, and the rotary plows, all continue popular; but the engineers in charge of their use have, through careful study and experiments, become able to specify, fairly accurately, the types most suitable for use under various conditions and with different types of motive power. While some localities still hold to opening the roads after the storm is over, the majority of snow fighters attack the snow at the commencement of its fall or shortly thereafter, and continue operations until the storm is past and the road cleared. When the latter method is used and the roads are kept open for constant traffic, mold-board plows or light V-type plows are invariably employed with high speed trucks for the motive power. The plows used vary in design only in the height and cross section of the mold board, and shape and strength of the V-plow, but there appears to be some difference of opinion regarding the model and power of the trucks to be employed. An engineer in central New York (Onondaga County) with considerable snow to handle, after experimenting with various trucks, has adopted a truck of rather heavy build as best suited for his snow re-

moval work; while engineers of Michigan, after similar study, believe a lighter and less expensive truck is suitable for all preliminary clearing.

Wide Cuts to Accommodate Snow from Subsequent Storms Now Becoming General Practice.—In localities with considerable seasonal snow fall and a general low temperature, which keeps the snow from melting during all or a part of the winter, the chief requirement appears to be to maintain wide cuts, where the topography will permit. While these wide cuts make useful roadways for traffic, their principal purpose, after a certain width adequate for traffic is cleared, is to provide room for the snow or future storms.

The widening of cuts to accommodate the snow of suceeding storms has now beome a well established practice. Of course this is nothing really new, but the engineers in charge have begun to realize its importance. After the truck plow is no longer adequate, the widening of preliminary cuts through deep snow is accomplished with heavy displacement plows and rotaries of one type or another, both classes of plow being employed with tractors. The displacement plow is very serviceable for this work, but as it rolls the loosened snow to the top of the adjacent bank, it occasionally builds up a wedge-shaped formation which acts as a wind break and causes drifts in the traveled way. This is prevented, in some instances, by an adjustable wing attachment in connection with the plow. The wing is attached to a post on the right hand side of the frame, in such a manner that it can be raised or lowered to a level with the height of the adjacent bank, with the cutting edge parallel to the horizontal plane, and the wing set at about an angle of 45 degrees to the axis of the cut. The wing in this position levels the top of the snow bank so that it will not act as a wind break. With the use of the rotary plow in widening operations, the wedge-shaped top is not formed, but a sheer bank with level top is provided.

In some cases when the snow has become hard or the bank is higher than the top of the rotors, the rotary plow is provided with an auxiliary attachment for convenience in the widening work. The device is attached to the rear of the rotary plow and loosens the snow, permitting it to fall to the road surface, where it is picked up and cast into the fields on the return trip of the plow.

Drift Prevention Continues as General Practice.—Drift prevention with snow fence or by other means continues to be popular. An engineer in Central New York reports that over some sections of his roads rotary plows were necessary for widening the cleared way before they had erected snow fences. After placing the snow fence, at studied locations, all widening was accomplished with truck-mounted displacement plows, with a substantial saving in operating expenses. Although snow fences of various types and design are being used in large quantities over the snow area, at times the appropriations for this purpose to not keep up with the demand, and in such instances numerous makeshifts are resorted to for overcoming the shortage. In one locality, discarded calcium chloride bags were strung on wire attached to posts. These were found useful for keeping the drifts from the traveled way. The wind resistance of the boards of wooden guard-rail is often the cause of drifted roadways, and the same boards at times interfere with the displacement of snow. The lower plank prevents the snow from being pushed laterally by the plows. In some localities, sections of wooden guard-rail are dismantled during the winter and the planks used together with chloride bags for improvising snow fences. The boards are bound together in temporary frames and the bags tacked in place. At the close of the snow season the boards are replaced in the guard-rail.

Snow Traps Prevent Drifting in Some Localities.—The formation of drifts in roadways is preventable to some extent, in territory with heavy snow falls and low temperatures, by plowing a path in the snow in the fields on the windward side of the highway. The plowed paths are called "snow traps." The idea is not entirely new, as it was formerly used in timbered country for the protection of logging roads from drifted snow. The traps are plowed from 75 to 100 feet away from the road and are made from 12 to 15 feet wide. One or more traps are plowed according to the nature of the terrain adjacent to the road and the amount of snow in prospect. The theory is that the traps stop the snow to some extent and keep it from drifting into the road. After each storm the runways are replowed and the snow piles up in high banks, which serve very well as wind breaks until the necessary quantities of regular fence can be financed and set.

Cost of Snow Removal Varies Over a Wide Range.—The engineer for a State in the middlewest believes that the cost of removing snow from the roads in one territory can be estimated from the cost of work over a similar section, provided the necessary records have been kept. A report compiled by one of the State highway engineers states that the average annual snow fall for the State varies from 30 inches at its southeast corner to 130 inches at its extreme northern limits. The State has a temperature varying from occasional zero weather in the southeast section to 50 degrees below zero at its northern limits. An extensive snow removal program is maintained which covers practically all sections of the State, no part of which is mountainous, and a most careful and complete study has been given to snow removal work. The studies included the preparation of a map of all the roads included in the snow removal program. The map shows the nature of the surrounding topography as affecting the drifting of snow. Snow removal work for the State is divided into five divisions and ten maintenance sections, each section being in charge of a maintenance supervisor who further subdivides his section into workable units. In some instances the work is parceled out to the counties, on a cost-plus basis, under contract to keep the State roads open. During the past winter, all division engineers, maintenance supervisors, and foremen were directed to keep accurate cost data of all snow removal operations. The records are to be segregated into convenient sections with designated termini, and are to be compared with similar areas on the topographical map. The various organizations were instructed to note all cost data on snow removal work; the records to include the equipment used and the hourly rental charges adopted; wages of men; estimated overhead; intensity and duration of storm; duration and estimated velocity of the wind density of the snow; temperatures during the storm and while removal operations are in progress; in fact each and every item to be noted bearing on the work involved, that would be directly or remotely useful in securing cost data. When these figures have been classified, and compared as to sections with similar topography, they will make available for that State actual cost data covering small and large sections of territory, over a region with snow precipitation averaging between 30 and 130 inches per year. With this information, should the State highway department wish to estimate the cost to remove snow from any particular section, they may do so after a study of the topographical conditions and the local weather bureau records, followed by a comparison of the data with a previously studied section of similar territory.

COST ANALYSIS OF SNOW REMOVAL IN MICHIGAN.—V. R. Burton, Engineer on Special Assessments, Michigan State Highway Department, gave the following in *Roads and Streets:*

Cost Analysis of Snow Removal.—The factors considered in the accompanying table of cost analysis were first temperature, second wind direction and third topography. That the cost per inch mile of snow removal varies also with the snowfall is true, but enough cases were not available to bring out this variation in detail except as shown in the table. These figures are derived from a cost computation over the entire 1924-25 winter system.

Each trunk line road across an entire county was considered a unit in most cases, and the average removable snow, temperature, wind direction and topography applied to this road. Trunk Line lengths across Michigan counties will average about twenty-five miles. There will be large variations from the average of the factors considered in even this short distance in the Upper Peninsula and therefore in some Upper Peninsula Counties the distance was reduced.

The cost per mile for each trunk line road in the county was computed from the cost records of the individual maintenance sections. The cost of snow fence is assumed to be a 2 per cent depreciation charge plus the labor of erection and dismantling. There is unquestionably a great difference in the efficiency of the organizations doing this work which is reflected in cost but the more glaring examples which were known to us have been eliminated and the others compensated for in the second part of the table.

The amount of removable snow was determined by snowfall records, temperature records and the dates on which our records show plows to have been used. The reduction secured from the reduction curve showed only from 1 to 6 in. reduction during the removal period. The snow which fell before and after plows were used varied from 1 to 30 in., in a total annual snowfall of from 25 to 60 in.

From the amount of removable snow and the cost per mile the inch mile costs were made up. These costs were grouped into four temperature ranges, first those which occur in sections which had a mean temperature during the removal of less than 18°. This includes all but one Upper Peninsula County. The second classification was from 18° to 20°, third from 20° to 22° and four from 22° to 25°.

Topography is classified as flat, which included the glacier lake beds and outwash plains, gently rolling the till plains; rolling the moraines and hilly the heavy moraines and rocky outcrops. This classification is admittedly vague and over as long a stretch as 25 miles subject to considerable variation. The predominating classification is used, however, and is in most cases, sufficiently accurate when dealing with so many large variables.

ANALYSIS OF SNOW REMOVAL COSTS
Winter 1924-1925.

Number of Counties studied	Mean temperature during removal period.	Inches removable snow variation.		TOPOGRAPHY: FLAT, Direction of Wind: // to ¼	FLAT: ¼	FLAT: ¼ to x	GENTLY ROLLING, Direction of Wind: // to ¼	GENTLY ROLLING: ¼	GENTLY ROLLING: ¼ to x	ROLLING, Direction of Wind: // to ¼	ROLLING: ¼	ROLLING: ¼ to x	HILLY, Direction of Wind: // to ¼	HILLY: ¼	HILLY: ¼ tox
			Actual Schedule of Unit Costs												
8	Below 18°	30-80	Average Inch mile cost		1.45									3.20	
			% of ¼ wind		100									100	
			No. cases		2									10	
11	18°-20°	7-20	Average Inch mile cost	1.74	1.92	2.61	1.60	1.85	2.86	1.66	2.29	2.13			
			% of ¼ wind	91	100	136	87	100	155	73	100	93			
			No. cases	1	4	4	3	5	5	1	4	4			
17	20°-22°	7-20	Average Inch mile cost	1.25	1.33	2.28	0.69	0.69	0.56	0.57	0.81	0.97			
			% of ¼ wind	94	100	171	100	100	81	70	100	120			
			No. cases	5	5	2	5	7	1	4	4	6			
8	22°-25°	5-30	Average Inch mile cost	2.81	3.93	4.32		2.48	2.97	2.54	2.00	2.79			
			% of ¼ wind	72	100	110		100	112	127	100	140			
			No. cases	2	2	3		4	1	1	4	1			
			Possible Schedule of Unit Costs												
8	Below 18°	30-80	Average Inch mile cost		2.00									3.50	
			% of ¼ wind		100									100	
11	18°-20°	7-20	Average Inch mile cost	1.70	1.90	2.65	1.70	1.90	2.65	1.70	2.10	2.50			
			% of ¼ wind	90	100	140	90	100	140	80	100	120			
17	20°-22°	7-20	Average Inch mile cost	1.25	1.40	2.00	0.60	0.75	0.90	0.65	0.80	0.95			
			% of ¼ wind	90	100	140	80	100	120	80	100	120			
8	22°-25°	5-30	Average Inch mile cost	2.70	3.00	4.20	2.00	2.50	3.00	1.80	2.00	2.80			
			% of ¼ wind	90	100	140	80	100	120	90	100	140			

Culture has not been considered as important as it should be put in those counties from 20° to 25° included in the cost analysis the flat and gently rolling land is largely cultivated land. There is a larger proportion of wooded land in the rolling land. In the counties below 18° the country is generally more wooded especially the two flat stretches noted. Conditions among counties in the same temperature classification are in general quite similar.

Wind direction is given as quartering, parallel to quartering and quartering to cross. Assuming 30 degree divisions of the quadrants for this classification. This information was secured from weather bureau reports of prevailing wind direction during the snow removal period.

Two tables are shown in the cost analysis, first the actual schedule of average unit costs and second a table of possible unit costs weighted both according to the number of cases to be had and from personal knowledge

of the class of work done in each case. This weighting was done to give a more consistent arrangement of percentage variations. It will be seen on comparison with the actual costs that this re-arrangement has been done without too serious mishandling of the actual costs.

Discussion of the Cost Analysis.—In discussing this cost analysis it should first be stated that except for the range of snowfall shown as below 18° there seems to be little or no relation between the amount of snowfall and inch mile costs over the range covered. That is, in a number of cases it cost just as much per inch to move 30 in. as it did to move 5. Above the 30 in. and with temperatures below 18° however, there is an apparent increase in cost as the amount increases. Due to the fact that in some cases the class of service was not comparable, for the present at least, only the averages will be used.

We should naturally expect that the inch mile cost should increase with the snowfall and if the costs of the next higher temperature classification are compared this is found to be the case. This is due to two reasons, first there begins to be at about a 30 in. amount of removable snow, as much more general use of tractor plows and these are more expensive units to operate than the trucks used for smaller amounts. Second, as the winter goes on, the accumulations of snow at the side is a more serious means of increasing the cost in the higher snowfalls, from the additional drifting caused by it and the increased difficulty of getting the snow back.

It might be assumed that the total cost of removal would vary more consistently with the number of trips made rather than with the total amount of snow moved during the season. This did not prove to be the case even though in some instances the number of trips exceeded the number of storms by 100 per cent. If the number of hours spent on the trip were taken into account they would of course be a direct index of the cost, but due to variations in the time of trips, the number of trips gives little information as to relative costs. The time consumed is in general proportional to the amount of snow moved when this time and snow moved is averaged over the whole season.

While there was some overlapping of unit costs by sections near the limits of the temperature division chosen, yet the general run of individual costs was quite consistent, really surprisingly so in the case of the 20° to 22° division. There are of course always bound to be inconsistencies due to the class of service rendered, efficiency of the organization operating, amount of traffic on the road, use or non-use of snow fence, etc., even if all our other factors were mathematically exact, which they are far from being.

The most remarkable variation in cost per inch mile is shown by the classification according to temperature. It should be remembered that this cost variation is due to the product of two factors, first the depth of drifting and second the cost of removing the particular class of snow encountered through that depth. It can easily be seen then that there may be a temperature at which a minimum cost may occur due to the minimum product and not the minimum of either factor.

Throughout all ranges of topography and wind conditions the cost per inch mile from seventeen different counties with a mean daily temperature of 20° to 22° is consistently less than for temperatures either above or below this temperature range. Drifting is not so serious at this temperature as it is at the lower temperatures and the cost of moving an inch of drifted snow is not so high as it is in the temperatures above. We have here then the condition of snow removal at the minimum cost per inch mile.

As the temperature drops below 20° the amount of drifting increases faster than the decreased cost of moving a lighter snow and we get increased costs. The inconsistency noted in the actual schedule of the table for the flat topography below 18° is explained by a difference in culture. The two instances studied are from Upper Peninsula counties where the land is much more wooded and hence protected from drifting.

As the temperature goes above 22° the snow gets heavier and more difficult to move since thaws are much more frequent. The cost of moving this kind of snow increases faster than the decreased amount of drifting. This may seem like a rather far fetched explanation to account for these cost variations and if the roads could be kept continually clear without any interruption of service it is doubtful if so marked a difference in cost would be shown. To permit a road to fill up and then remove the parked snow after it has frozen and thawed for a day or two is a certain means of increasing costs. Increased speed of removal in these regions of higher temperature will unquestionably lower the averages given.

In one county, Monroe, with a temperature average of 25.7° and a 10 to 12 in. amount of removable snow there was some indication that the decreased amount of drifting had lowered the unit cost in spite of the increased weight of the snow but not enough data was at hand to draw any definite conclusion.

Effect of Topography on Cost of Snow Removal.—Let us now examine the effect the difference in topography on the inch mile cost of snow removal. It will be noticed that the 22° to 25° temperature range with a 5 to 30 in. variation in removable snow the cost decreases fairly uniformly from flat to rolling country. In our adjusted table this varies, using the quartering wind as a standard from $2 to $3 per inch.

In the flat country included in these counties from which the data on temperature range from 18° to 25° was derived, as has been stated, a majority is cultivated land. On a terrain of this character the wind gets a long clear sweep across the fields picking up the snow as it travels along the surface and deposits it at the first obstruction to its progress. This obstruction need not be any more serious than a woven wire fence especially if weeds and brush are allowed to stand along the fence row. Tighter obstacles such as picket or board fences of course increase the amount of drifting. The various rights of way of from 50 to 66 ft. do not give sufficient clearance between road and fence, and the drift forms in the roadway.

Drifts in this sort of country are characterized by only medium but very uniform depths extending for long distances along the road. There are no appreciable side slopes to absorb any of the snow accumulation or break up the sweep of the wind and the top slopes of the drift is therefore very flat throughout most of its length. These long comparatively shallow drifts are removed and the ridge accumulation along the side aggravates further drifting until before the winter is over surprisingly large amounts are on the ground.

The factors which tend to reduce the cost through this temperature and snowfall range over the more rolling country are several. First, as has been stated, especially in that part classified as rolling, more wooded land is seen. Second, where the snowfall range is no higher than it is and with temperatures this high the storage capacity of the side slopes of the larger cuts is not so often exceeded and less snow drifts in the roadway. Finally, long stretches of roadway on fills will be swept bare of any snow at all. As we pass from flat through gently rolling country to rolling there are of course, all sorts of variations of these factors.

On examining the next lower temperature class from 20° to 22° the importance of the flat topography is still evident, although the cost is reduced. The gently rolling country shows the minimum cost, although between rolling and gently rolling not much difference is seen. The importance of the larger drifts in rolling country begins to be evident, however, with the increased drifting caused by the drop in temperautre. The increased amount, however, does not yet overbalance the decreased cost of the lighter snow.

When the temperature drops to from 18° to 20° the increased drifting materially raises the unit costs. The larger drifts cause much more trouble, and it is now more a question of depths of snow than it is the quality. As we would expect, little difference is seen between flat and gently rolling country. The heavier cuts in the rolling country are now of somewhat more importance in their reflection of inch mile cost.

When we get into the Upper Peninsula the cuts in the rolling and hilly country are of much more relative importance and cause a serious increase in cost. These extremely bad cuts and the heavy drifts which form in them not only influence the cost from their depth alone, but due to the rapidity with which they fill, will not permit of the continuous method of removal so essential to low costs.

Summing up the discussion of the effect of topography on snow removal cost, then, we see that from a certain temperature of minimum inch mile cost the cost increases with the roughness of the topography as the temperature falls and decrease with the roughness as it rises.

Prevailing Wind Direction as Factor in Drifting.— As was shown in a preliminary study of Michigan snow problem, the matter of wind velocity for a range in value no greater than those shown in our state is unimportant when studying a full season's work. The prevailing wind direction, however, has been found to be a more considerable factor than was at first supposed when applied to locations of similar snowfall and temperature. There are more inconsistencies, naturally, in a study of so variable a quantity because a few storms which do not come from the direction of the prevailing wind may cause trouble on a section comparatively drift free when normal winds are blowing. In general, though, where the larger number of cases are compared cost variations are fairly consistent, at least so far as sign is concerned.

The reason that the amount of snow drifting into the road varies with the direction of the winds is perfectly obvious, yet it may be well to state it. There is no less snow moving along the surface in a parallel wind than in a cross wind, but the axis of the drift is parallel to the direction of the wind. The inclination of the wind's direction to the center line of the road, then, largely determines whether or not a drift of given length will reach to the roadway. By length we mean, of course, its direction parallel to the wind.

The quartering wind is adopted as a standard of comparison, as it is much more frequently met in our state, where the prevailing winter winds are largely N.W. and S.W., quartering our section line roads. About all that we can safely say at present about these variations is that with the quartering wind as a standard it costs from 10 to 20 per cent less on those roads whose prevailing wind direction is from parallel to quartering, and 20 to 40 per cent more on those roads where this direction is from a quartering to cross wind.

This completes our cost analysis, and I wish to again emphasize the fact that these figures shown as possible costs are tentative. They are the only ones we have which are at all reliable, but are certain to be modified as our range of snowfall studied is increased and a sufficient number of years' records is available to bring the costs to a closer approximation to the mean. It is felt, however, that the method of comparison outlined may prove of value to those whose situation is somewhat similar to our own. It is a logical method and so far as is known is the first of its kind attempted.

Glossary of Terms in Road Field

Defined in Construction Manual of Ohio Department of Highways and Public Works

Words and ideas are just as much the tools of the engineering construction field as are the mixer and drag-line. But the former are in the apparently abstract and hence need definition. New terms and new phrases come into existence and old words and phrases shade in meaning as times goes by. The following glossary of terms is a guide for all interested parties working on highway and bridge work in the state. It helps the engineer, contractor, director, supervisor, attorney and others to talk the same language in matters relating to highway construction.

GLOSSARY OF TERMS

Abrasion—The act of wearing or rubbing off or away by friction or attrition.

Abutment—A supporting wall carrying the end of a bridge or span and sustaining the pressure of the abutting earth. The abutment of an arch is commonly called a bench wall.

A. C. B.—Asphalt Cut Back—A heavy asphalt fluxed with naphtha to reduce viscosity. It is liquid at low temperature, but when mixed with aggregate and exposed to the air rapidly loses its fluxing agent, leaving a viscous matrix.

A. E.—Asphalt Emulsion—A mixture of asphalt and water which has an emulsifying agent incorporated. The consistency can be modified by the addition of soft water. The emulsion is broken by agitation, such as mixing with stone or by chemical action of either acid or base, or by physical action of mixture with dust. The asphalt is precipitated, leaving water content free.

Annealed—Subjected to a high heat and cooled by a gradual process for the purpose of softening and rendering less brittle.

Approach Slab—A reinforced concrete slab spanning the backfill behind the abutment.

Asphalt—Solid or semi-solid native bitumens, solid or semi-solid bitumens obtained by refining petroleums, or solid or semi-solid bitumens which are combinations of the bitumens mentioned with petroleums or derivatives thereof, which melt on the application of heat, and which consist of a mixture of hydrocarbons and the derivatives thereof.

Arch—A curved structural member which spans an opening and supports the adjacent members by resolving vertical pressure into horizontal or diagonal thrust. **Arch Bridge**—A bridge whose main members are arches. **Bow String Arch**—An arch having a bottom chord. **Filled Spandrel Arch**—An arch bridge, the roadway of which is supported by a fill of earth or other material over the arch ring. **Open Spandrel Arch**—An arch bridge, the roadway of which is supported by columns from the arch rib. **Through Arch**—An arch bridge, the roadway of which is below the crown of the arch. **Arch Rib**—An arch member of a bridge in cases where the roadway is supported by two or more separate arches per span. **Arch Ring**—The arch member of a bridge in cases where the roadway is supported by a single arch for each span.

Arris—The external edge formed by two surfaces, whether plane or curved, meeting each other.

Axis—A line around which the parts of a body or system are symmetrically arranged.

Back Wall—A wall projecting from the bridge seat to the top of the earth fill, to prevent the earth from flowing onto the bridge seat, and to support the approach slab.

Base Plate—Plate upon which a rocker or roller rests.

Batter—The slope or inclination of the face or back of a wall from a vertical plane.

Batter Pile—One driven at an inclination to resist forces which are not vertical.

Berm—That portion of the roadway extending from the edge of the pavement to the inside of the ditch.

Billet Steel—Steel east in billet form, either by the Bessemer or open hearth process. Does not include high carbon or rerolled steel.

Binder—A foreign material introduced into the mineral portion of the wearing surface for the purpose of assisting the road metal to retain its integrity under stress, as well as, perhaps, to aid in its first construction. (2) The course, in a sheet-asphalt pavement, frequently used between the concrete foundations and the sheet-asphalt mixture of graded sand and asphalt cement.

Bitumen—A mixture of native or pyrogenous hydrocarbons and their non-metallic derivatives which may be gases, liquids, viscous liquids, or solids, and which are soluble in carbon disulphide.

Bituminous Concrete Pavements—One composed of broken stone, broken slag, gravel, or shell, with or without sand, portland cement, fine inert material, or combinations thereof, and a bituminous cement incorporated together by a mixing method.

Bituminous Macadam Pavement—A pavement having a wearing course of macadam with the interstices filled by a penetration method with a bituminous binder.

Bleeding—The exudation of bituminous material on the pavement surface after construction.

Bolster—A casting supporting the fixed end of truss or girder.

Breast Wall—A wall built to prevent the falling of a vertical face cut into natural soil.

Bridge—A structure for carrying traffic over a stream or gully, the paving material or wearing course resting directly on the floor of the structure.

Bulking—The separation of the particles and increased volume of aggregate due to the presence of a small per cent of water.

Bulkhead—A partition or form used for shutting off a part of given space.

Bumpometer—A straight edge equipped with wheels and an electric signaling device for testing the smoothness of pavements.

Buttress—A vertical projecting piece of masonry built in front of a wall to strengthen it.

Camber—The rise of the center of a bridge or structural member above a straight line through its ends.

Catch Basin—A receptacle for diverting surface water to an underdrain, having at its base a sediment bowl.

Caulk—To fill seams or joints in such manner as to prevent leaking.

Cement Gun—A trade name applied to an apparatus used for the placing of mortar under pressure, the characteristics being that the mortar is forced dry to the nozzle, hydration taking place at the nozzle, and coincident with the application.

Center and Centering (for arches)—False work for an arch.

Chips—Small angular fragments of stone or slag containing no dust.

C. O.—Cold Oil—Asphalt fluxed with 22 per cent to 30 per cent of naphtha, so that it can be applied cold.

Cofferdam—An enclosure built in the water, and then pumped dry, so as to permit masonry or other work to be carried on inside of it.

Consistency—The degree of solidity or fluidity of materials.

Coping—A top course of stone or concrete, generally slightly projecting, to shelter the masonry from the weather, or to distribute the pressure from exterior loading.

Counterfort—Vertical projections or reinforced masonry built along the back of a wall to strengthen it.

Counter Sink—To cut away material from the edge of a hole in such manner that the head of a screw, rivet or bolt will be flush with the surface.

Creep—A slow, natural downward movement of loose material on hillsides.

Creosoting Oil—Tar distillates, tars and mixtures of tars with tar distillates which are used by a process of impregnation in the preservation of wood. Note: This term was originally confined to the heavier coal-tar distillates carrying a large proportion of the creosols which were present in the tar before distallation.

Crown—Highest point on cross-section, usually the center.

Crown—(of an Arch)—The highest point of an arch rib or ring.

Crusher Run—The total unscreened product of a stone crusher.

C. T.—Cold Tar—Tar fluxed with some of the lighter distillates, so that it can be applied cold.

Culvert—Roadway structure of a span of more than one foot, designed to support a super-imposed load of earth or other filling material.

Cut Back Products—Petroleum, or tar residums, which have been fluxed with distillates.

Dead Load—The weight of structure, together with fill, pavement and other permanent loads.

Deformed Bar—A steel bar for reinforcing concrete and which has projections on its surface in order to secure a mechanical bond between the concrete and the steel. These projections are formed either by passing the bar through specially shaped rolls or by twisting the bar.

Dowels—Metal bars used to connect two sections of masonry.

Drift Punch—A smooth, tapered pin for bringing rivet holes into alignment.

Drop Forged—Forged between dies by means of a drop hammer or drop press.

Drop Hammer (Pile Driving)—One which is raised by means of a rope or cable and then allowed to drop.

Dry Masonry—Masonry laid up without mortar.

Ductility—The physical characteristics of a material which permits it to be distorted without breaking.

Easement or Easement Deed (Right-of-way)—A grant of an indefinite right of use, for a certain purpose, at the will of the grantee.

Emulsion—A combination of water and oily material made soluble through the action of a saponifying or other agent.

End Box—Gussets, shoe cover plates and other details at shoe pins or truss spans.

Extrados—The outer or convex surface of an arch.

False Work—Temporary support for a structure during construction.

Field Coat—A coat of paint put on steel or other material after or just prior to erection.

Fillet—A concave junction or molding of two surfaces.

Flange—A projecting edge or rim.

Flash Point—That degree of temperature at which a given substance gives off vapor in sufficient quantity to flash.

Flow Line—(1) The bottom of a steam bed. (2) The lowest point of the inside diameter of a pipe.

Flux—Bitumens, generally liquid, used in combination with harder bitumens for the purpose of softening the latter.

Gram—.0022 of a pound.

Gunite—Mortar placed with a cement gun.

Gutter—The artificially surfaced and generally shallow waterway, provided usually at the sides of the roadway for carrying surface drainage. Occasionally used synonymously with ditch, but incorrectly so, as gutters are always paved or otherwise surfaced, and ditches are not.

Gusset Plate—A plate connecting two or more structural members not in the same straight line.

Hanger (Through Arch)—A vertical tension member transmitting the load to the arch rib.

Hardpan—A soil which may be either (1) a very dense subsoil, such as tough clay; (2) a cemented layer in the soil, where ground waters have precipitated a local binder of silica carbonates, iron oxides, etc.; or (3) dense clayey glacial drift.

Header—(1) A curb placed across the road at the end of a pavement and set flush with the top of the pavement to hold the end of the pavement in place. (2) A stone or brick laid with its largest dimension at right angles to the face of the masonry.

H. O.—Hot Oil—Asphalt of such consistency that it must be heated above 225 deg. F. to be applied effectively.

H. T.—Hot Tar—Tar of such consistency that it must be heated above 175 deg. F. to be applied effectively.

Intrados—The inner or concave surface of an arch.

Invert—That part of a pipe or sewer below the spring line.

Jute—A fibrous, vegetable substance used for caulking.

Knapping—Breaking up coarse aggregate by means of hammers or sledges.

Laitance—A thin layer of inert material which collects on the surface of concrete when it is deposited and forms a light chalky crust on hardening.

Leads—The upright parallel members of a pile driver which support the sheaves used to hoist the hammer and piles, and which guide the hammer in its movement.

Macadam—A road crust composed of stone or similar material broken into irregular angular fragments compacted together so as to be interlocked and mechanically bound to the utmost possible extent.

Mastic—A mixture of bituminous material and fine mineral matter suitably made, for use in highway construction and for application in a heated condition.

Mat—A bituminous layer of appreciable thickness, generally formed on top of a pavement by the application of one or more coats of bituminous material with gravel or stone chips added.

Mix or Mixture—Sometimes used to denote the proportions of the several parts of concrete.

M. T.—Medium Tar—Tar of such consistency that it must be above 100 deg. F. to be applied effectively.

Natural Bed—The surface of a stone parallel to its stratifications.

Ogee—A moulding on the shape of an S.

Oil Asphalt—Asphalt manufactured directly from petroleum.

Ordinate—The perpendicular distance from a point on the tangent to a point on the curve.

Organic—The product of animal or vegetable life.

Penetration—The consistency of a bituminous material expressed as the distance that a standard needle vertically penetrates a sample of the material under known conditions of loading, time and temperature.

Penetration Method—The method of constructing a bituminous macadam pavement by pouring or grouting the bituminous material into the upper course of the road material before the binding of the latter has been completed.

Pile—A member usually driven or jetted into the ground and deriving its support from the underlying strata, and by the friction of the ground on its surface.

Pipe Cap—A metal and wood cap placed over the head of a pile to protect it while driving.

Plumbs—Stones or boulders of a volume of more than one cubic foot, incorporated in concrete masonry.

Pointing—Filling joints or defects in the face of a masonry structure.

Pot-Hole—A hole extending below the wearing course.

Precast Concrete—Concrete which is cast into forms and then hoisted and set in place.

Profilometer—A machine for recording the irregularities of the surface of the pavement.

Quartering—Dividing a sample of material by thoroughly mixing it and striking it off into four parts. The one-fourth part is again mixed and quartered and so on until the volume is the amount required for testing.

Rip Rap—Rough stone of various sizes placed compactly or irregularly to prevent scour of water.

Road—A highway outside of an urban district.

Road Metal—Broken stone, gravel, slag or similar material used in road and pavement construction and maintenance.

Road Bed—The portion of the roadway extending from shoulder line to shoulder line; in other words, the subgrade and shoulders considered as a unit.

Rock Asphalt—Sandstone or limestone naturally impregnated with asphalt.

Rocker—A casting supporting the free end of a span, allowing expansion by a rocking motion of the casting.

Rubble—Field stone or rough stone as it comes from the quarry. When it is of a large or massive size it is termed block rubble.

Scarify—To loosen or disturb superficially.

Screen—In laboratory work, an apparatus, in which the apertures are circular, for separating sizes of material.

Screenings—Broken rock, including the dust, of a size that will pass through one-half to a three-quarter inch screen, depending upon the character of the stone.

Seal Coat—A final superficial application of bituminous material during construction to a bituminous pavement.

Seepage—Quiet emergence of water along some rather extensive line or surface, as contrasted with a spring whose water emerges from a single spot.

Sheet Piles—Piles driven in close contact in order to provide a tight wall, to prevent leakage of water and soft materials; or driven to resist the lateral pressure of adjacent ground.

Shoe—(1) A metal protection for the foot or end of a pile. (2) That portion of a superstructure resting directly upon the abutment.

Shoulder—See Berm.

Skew—The angle which the center line of a bridge makes with a line normal to the center line of the roadway.

Slope Wall—A wall to protect the slope of an embankment or cut.

Slope Stakes—Stakes set to indicate the top or bottom of a slope.

Slump—The vertical distance which concrete subsides from its moulded shape when tested for consistency by the standard method.

Snow Fence—A structure erected for the purpose of forming artificial eddies on the windward side of a cut at sufficient distance away to cause snow to deposit between the snow fence and the cut.

Soffit—The under or concave side of an arch.

Spall—A chip or small piece of stone from a large block.

Span—The distance between the faces of the abutments of a bridge on the center line of the roadway.

Springing Line—The line in which the soffit of an arch meets the skewback.

Stretcher—A stone which has its greatest length parallel to the face of the wall.

Subgrade—The upper surface of the native foundation on which is placed the road metal or the artificial foundation, in case the latter is provided.

Subsoil—The bed of earth immediately beneath the surface soil.

Sump—A well into which water may be conducted by ditches to drain other portions of the work.

Surface Treatment—Treating the finished surface of a roadway with bituminous or other material.

Tailings—Stones, which, after going through the crusher, do not pass through the largest openings of the screen.

Tar—Bitumen which yields pitch upon fractional distillation and which is produced as a distillate by the destructive distillation of bitumens, pyro-bitumens, or organic material.

Telford—An artificial foundation formed of stone about eight inches thick laid by hand and closely packed together.

Templet—A gauge, pattern or form for testing a surface.

Toughness—The property of resistance to breaking by impact.

Tremie—A pipe or conduit having a valve or door on the bottom for placing concrete under water.

Viscosity—The measure of the resistance to flow of a bituminous material, usually stated as the time of flow of a given amount of the material through a given orifice.

Volatile—Applied to those fractions of bituminous materials which will evaporate at cli-temperatures.

Wearing Surface or Course—The course of the pavement exposed to traffic.

Weep Hole—A hole through an abutment or retaining wall for drainage.

Wing Wall—An extension of an abutment wall to retain the adjacent earth.

Traffic Direction and Regulation

Compiled by Edward W. Tree, Traffic Engineer, New York City

I—TRAFFIC DIRECTION.—Prior to the year 1924 there was little if any standardization of highway markers and signs with the exception of those adopted by the Mississippi Valley Association of State Highway Departments. As a result of the activities of this association and their work, however, a widepread interest was manifested in the subject, and, accordingly, in 1924 the American Association of State Highway Officials at their annual meeting in San Francisco requested the Secretary of Agriculture to work out a comprehensive system of national highways and to formulate "a standard system of numbering and marking highways of interstate character."

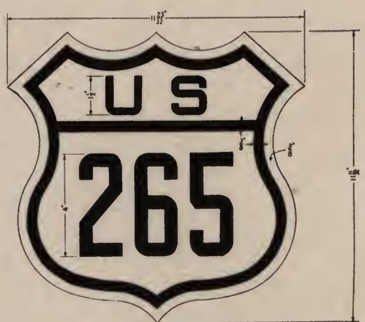
The Secretary complied with this request and on February 20th, 1925, appointed a group of men known as the Joint Board on Interstate Highways. On October 26th of the same year this Board submitted its final report. The markers and signs so standardized have had the unanimous indorsement of American Association of State Highway Officials, and Secretary Hoover's Two National Conferences on Street and Highway Safety. A large number of the states and numerous county organizations throughout the nation have adopted the standard. The U. S. Bureau of Public Roads has also given its approval and adopted the standard markers and signs for use on all Federal Aid highways.

The system of standardized signs and markers, as thus adopted and approved, has been developed in a series of working drawings prepared by the U. S. Bureau of Public Roads and the following material and illustrations have been selected from the first edition (January, 1927) of the Manual and Specification for the Manufacture, Display and Erection of U. S. Standard Road Markers and Signs as Adopted by the American Association of State Highway Officials.

GENERAL DESIGN OF MARKERS AND SIGNS.—This set of designs is based on definite principles calculated to produce uniformity of significance in the signs themselves, and make familiarity with them easy to acquire on the part of the most casual driver. These principles are a set of shapes each having its own significance; a set of color combinations each having its own significance and a few obvious symbols.

Shape.—The octagonal sign is used to indicate "Stop," where for any reason such action is necessary. The diamond shaped signs are used to indicate any condition inherent in the road itself requiring slow speed and caution on the part of the driver. The circular sign is used as an advance warning at railroad grade crossings only. The square shaped signs are used to indicate any condition requiring caution that is not inherent in the road itself, but which is due to contiguous or adjacent conditions which often are also intermittent. The rectangular shaped signs of various dimensions are used to carry directions, information and restrictions of use or benefit to the driver. The arrow shaped direction sign may be substituted for the rectangular direction sign.

Route Markers.—Route markers to carry the designations assigned to various routes are of various distinctive designs. For the United States highways the standard outline of the official shield of the United States is used. On state roads that are not U. S. highways the several states use other appropriate devices, such as the Covered Wagon in Nebraska, the conventional Sunflower in Kansas, the Indian Head in North Dakota, the North Star in Minnesota, the Triangle in Wisconsin, the Keystone in Pennsylvania, etc. Several states including Arkansas, Illinois, Indiana, Ohio and South Dakota, use the state outline as a distinctive marker.



M-23 FOR CITY USE

M-3 FOR GENERAL USE

M-4


M-19


M-19A

Color.—All signs of a precautionary character, including the circular railroad sign, the octagonal stop sign, the diamond slow signs, and the square caution signs have black designs on a yellow background. All direction, information and restriction signs are black on a white background. Route markers have black copy on white background. (A few of the states are exceptions to this.)

Symbols.—The symbols used on the various signs are those for railroad grade crossings, both for single and multiple tracks, for left and right curves and turns; for reversed curves and turns; the arrow on the directional sign and the arrow which accompanies the route marker.

New Designs.—If a state desires a sign for general or special use that is not included in the list of standard signs, request for such a sign should be made to the U. S. Bureau of Public Roads and a standard design will be made up in co-operation with the state requesting it. The design will thereafter be included in the list, and any other state wishing a sign for the same purpose will find it provided among the Standards.

DESCRIPTION OF MARKERS AND SIGNS.—The Standard U. S. Route Marker, M-3, Plate 1, which is a shield bearing the name of the state, the number of the route and the letters "U. S.," shall be used in marking the United States Highways only. The background color of the shield is white and the design black.

City Markers.—The color scheme is the same as for the Route Marker. City Markers, M-23, Plate 1, are to be of the same outline as the Standard Marker, but with reduced dimensions and with the name of the state omitted. This marker is for use when a smaller sign is desired in lieu of the Standard Marker in congested districts of cities or towns.

U. S. Directional Letters.—The small shield M-4 L and M-4 R, Plate 11, bearing the letter "R" or "L" is for use immediately below the Route Marker where required to indicate that the United States Highway deviates to the right or left at the next intersection.

Confirmatory Arrow.—The Confirmatory Arrow M-19 A, Plate 11, is to be mounted immediately below the Route Marker, M-3, to confirm an indicated deviation or branching of the route. It is for use immediately at the point where the deviation of the route occurs, rather than in advance of the branching. Directional Letters M-4 are for general use in advance of a deviation in route. However, where its use will cause no confusion, this Arrow, M-19, may be used instead of the Directional Letters, M-4, below the Route Marker M-3, in advance of a deviation or branching of a route. A Double Arrow, M-19A, Plate 11, is also provided for use where a route goes in both directions. The color scheme of this sign is the same as for the Route Marker, M-3.

Junction Signs.—The Junction Sign, D-4, Plate 11, is for use in advance of points where two or more routes meet or cross. It does not carry the number of the route on which it is erected, but only the number or numbers of those routes which are intersected. It should be used when one route comes into another and does or does not follow along with it. This is primarily a directional sign and not a caution sign and its color scheme is the same as for Route Marker M-3.

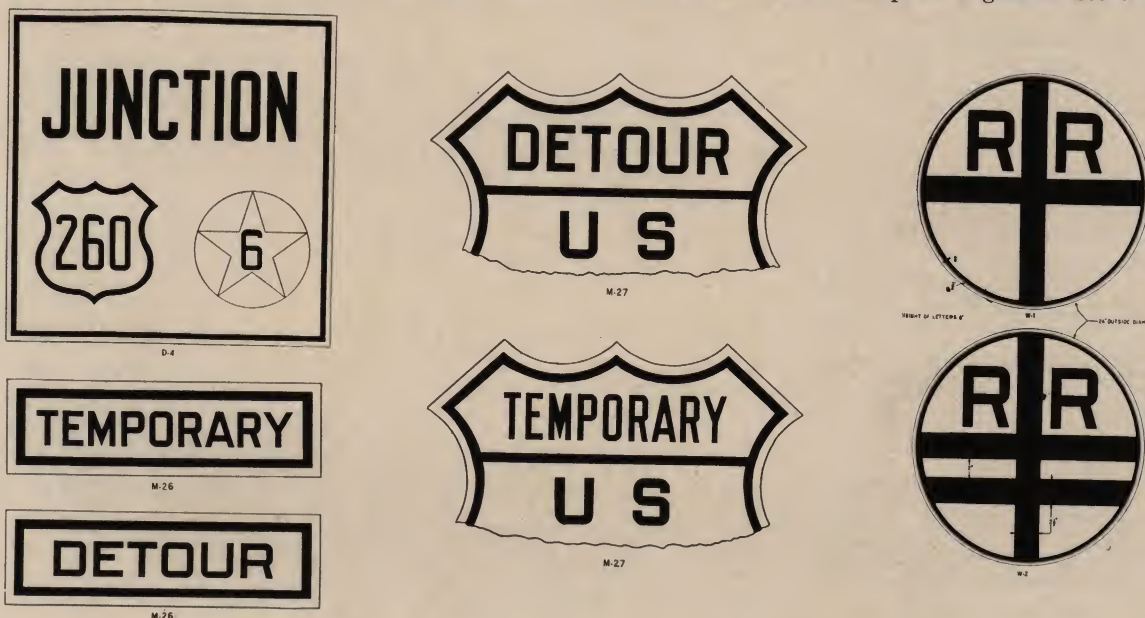
The standard design D-4 shows a combination involving two routes, one United States Highway and one State Road, in addition to the route on which the sign is to be erected. The design is to be altered to provide for a single route or even a third route to fit the requirements of each particular case. It is not necessary, and will not be possible in some cases, to use the state emblem with a state road number.

Detour Markers.—The general forms of Detour Markers provided are:

(a) The first form of Detour Marker consists in the use of a rectangular plate containing the word "Detour" or "Temporary" displayed just above the standard route marker. This rectangular plate is as shown in design M-26, Plate 111.

(b) The second form of the detour marker consists of the standard route marker with the following two changes in same: (1) in place of the name of the state, the word "Temporary" or the word "Detour" is substituted as shown in Design M-27, Plate 111; (2) the number of the route is left blank on the shield until it is learned on what route the sign is to be used and then the proper number is painted, or marked with crayon in the blank space, the same as on the standard marker.

CAUTION, SLOW AND WARNING SIGN SERIES.—These three series comprise a general set of signs to cover a large variety of conditions which it is desirable to meet in the interest of safety. The color scheme for these signs is yellow background with a black design. The yellow shade is that recommended by the Sectional Committee on Color Code of the American Engineering Standards Committee, and liquid samples of the standard yellow have been placed in the hands of each state highway department. Some manufacturers have indicated their intention of producing the specified shade under the name of "Federal Yellow."



Stop Sign, W-3.—This sign is for use at places on a highway where traffic is required to stop. Ordinarily, such points will be at railroad grade crossings, where stops may be required by law; at the intersection of two main highways; and at the junction or intersection of a cross-road with a main highway. The latter use of this sign will be the most common and will require the erection of the sign in a position to be visible and to warn traffic approaching the main route.

The Stop Sign shall ordinarily be erected on the side road 25 to 50 ft. from the point of potential danger, but this distance can not be fixed, and where traffic would ordinarily not be slowed down before reaching such a Stop Sign, the Slow Sign, C-5, Plate XXI, should be displayed about 350 ft. in advance of it.

It is intended that additional wording may be used in the upper and lower blank spaces of the Stop Sign, the wording to depend upon state legal requirements and the necessities of the case. The copy used will

ordinarily be "State Highway," "Trunk Road," "Arterial Highway," "State Law," "Thru Highway," "Thru Traffic," etc. In general, one word should be placed in the upper space, and one word in the lower space.

Rairoad, W-1 and W-2.—The Railroad Grade Crossing Signs ordinarily should be erected 350 to 450 ft. from the point of potential danger. Ordinarily 350 ft. should be used under normal conditions. The proper distance at any place will depend upon the usual speed of traffic at that place, the character of alignment and the nature of topography.

Turn and Curve Sign, C-6 and C-3.—A Turn Sign, C-6 L and C-6 R, Plate XXI, should be used where a

tle Guard," "New Grading," "Pavement Ends," etc., clearly indicate their intended use.

School Zone, Hospital Zone, Cross Road, etc.—The square Caution Signs, using the color scheme of the Slow and Warning series, are intended for use where the need for caution arises from some condition not inherent in the road itself, but due to contiguous conditions often, but not always, of an intermittent nature. This group of signs includes the Cross Road C-15, Side Road C-16, School Zone, C-10, and the Hospital Zone C-9. These may be combined when desirable. Their use and placement follow the same general rules as for Slow and Warning Signs.

W-3

C-1

C-6

D-12

C-3

C-5

D-11

curve has a radius of 200 ft. or less and Curve Sign C-3, Plate XXI, should be used on curves having radii between 200 and 600 ft. No Curve Sign should be used if the deflection angle is less than 15 degrees.

Hill Sign, C-1.—A Hill Sign, C-1, Plate XXI, should ordinarily be used only on descending grades steeper than 7 per cent and longer than 200 ft., and on 6 per cent grades if longer than 300 ft.

"Slow" Sign, C-5.—The "Slow" Sign, C-5, Plate XXI, should be used only where for safety, careful driving at a reduced speed is necessary.

This sign may be used in conjunction with other standard signs at particularly hazardous locations. When used in conjunction with other signs it should be erected 100 ft. in advance of the other sign, except when used as an advance warning for a "Stop" sign. The use of the "Slow" sign in conjunction with other signs is not recommended except for unusual cases.

Miscellaneous Signs.—There are a number of miscellaneous condition signs in the Caution Series for uses indicated clearly by the following: "Loose Gravel," "Fresh Oil," "Soft Shoulders," etc., are to be used where characterized conditions exist, and should usually be erected on temporary supports. "Narrow Bridge," "Narrow Road," "Low Bridge," "Draw Bridge," "Cat-

DIRECTION AND INFORMATION SIGN SERIES.—This series of signs is intended to furnish the traveler with directional and general information, but involving nothing of a precautionary nature. The signs are generally rectangular in outline, and the color scheme is black on a white background.

City and Village Signs.—Signs D-11 and D-12, Plate XIX, are for use at entrances to cities, villages or other well defined and named settlements or communities. These signs will face incoming traffic, and the reverse of the signs may be used to carry additional information.

General Directional Signs.—For indicating direction and distance to a place two types of signs are provided; a solid design and a slat design. Each has its own merits and either may be used at the discretion of the state highway department.

Design D-1 and D-1 S, Plate XVIII show the two designs. It is desirable to reduce the number of place names on any one sign to four so far as this may be done. This makes the design clearer to read. If additional place names are considered worthy of mention, additional signs should be placed at other points on the road.

II—TRAFFIC REGULATION.—The use of mechanical traffic signal equipment to control and safeguard the movements of vehicles upon streets and highways

has become a widespread practice during the last few years. For all general purposes traffic signals may be divided into two groups:

1. Warning or caution signals which use one color continuously or by flashes, to indicate the need of caution due to the presence of dangerous conditions.
2. Control signals, either hand or electrically operated, in which different colors become alternately visible for a fixed period of time during which traffic shall comply with the meaning conveyed by the color shown.

C-9 C-10 C-15 C-16

Each of these two types of equipment has definite and separate uses in the field of traffic control. When and where each type should be employed depends upon the nature and volume of traffic to be handled. Such information should first be secured through a traffic survey. This should cover, in detail, the character of traffic flow, the growth of traffic density, and the physical characteristics of the street plan. Studies should also be made of the character, location and causes of traffic accidents. Pedestrian traffic and the parking of vehicles are also elements to be considered and data covering these points should likewise be obtained. The compilation, study and intelligent use of such data is primarily an engineering problem. Before traffic signals of any kind are installed such competent advice should be sought.

In the field of traffic control there has been a notable lack of standardization. Some work has been done along this line, however, by a National committee on Municipal Traffic Ordinances appointed by Secretary of Commerce Hoover, the American Engineering Council, the New York Conference of Mayors and other Munipical Officials and the Empire State Gas and Electric Association. The codes being prepared by the first two mentioned agencies are now in the course of preparation. The report of the Joint Committee on Traffic Control Signal Systems of the New York State Conference was issued in May, 1927, and this material, in part, has been compiled from that source. The report, in general, suggested uniform standards for consideration by city officials and is a collection of information for the guidance of municipalities and lighting companies planning local installations.

Warning Signals

So far as the use of the first or cautionary type of signal is concerned, there has been a general criticism on the part of traffic engineers that its use has been too greatly restricted, and that "stop" and "go" signals have been used in fully 50 per cent of the cases where purely from an engineering standpoint the cautionary type should have been employed.

Generally speaking, the cautionary amber flashing signal, either electrically or acetylene gas operated, should always be used to safeguard an intersection until such time as the density of traffic as determined from a survey shows that a more expensive type of signal is warranted.

Control Signals

Colors.—The colors used in traffic signals are Red, Green, and Amber. In traffic warning signals, Amber only should be used.

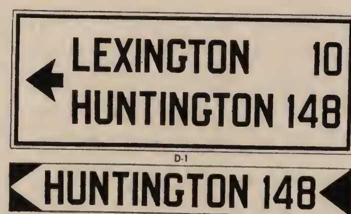
Meaning of Colors.—Red should always mean "Stop." It should never be used as a warning or cautionary signal. Green should mean "Go." Amber should mean "Proceed with Caution." It should be used exclusively and only for precautionary signals, either fixed or flashing. In order to avoid confusion, all other use of Red, Green or Amber lights, so located that they may be mistaken for traffic signals, should be discontinued.

Turns.—At all intersections where traffic is controlled by signal light turns should be made on green light only, except:

(a) As otherwise directed by a police officer on duty at intersection who should have full authority over all turns.

(b) Where diagonal streets, short blocks or other unusual traffic conditions make a variation necessary or desirable and in such cases directions to traffic should be clearly posted.

Pedestrian Traffic.—Pedestrians should be permitted to cross an intersection only in the direction of moving



D-1 D-15

traffic or when all traffic is halted. This can be accomplished by local ordinance supplemented by education.

Clearing Intersections.—An interval of clearance between the change of traffic signals to permit vehicles and pedestrians already in the intersection to reach the opposite side before the direction of traffic changes may be provided, and, if so, should be indicated by showing red lights in all four directions.

Location of Signals.—It is impossible to suggest a standardization for the location of traffic control signals, as local street conditions and available finances will, of course, govern the actual layout. The various methods in use at the present time, listed in the order in which they should be given precedence, are:

(1) Four lights, one on each corner, each light showing only in one direction, the controlling light in each case being the one on the far right corner to approaching traffic.

(2) Two lights placed on diagonally opposite corners, each one showing in two directions.

(3) One light located on one corner and showing in four directions.

A signal suspended over an intersection is not as desirable as one placed on a standard and located on the side of the street.

Height and Types of Signals.—The height of traffic

control signal lights should be such that they will be plainly visible to approaching traffic at a point 50 ft. from the intersection.

The various types of installations and their usual height are given in Table I. The location of each type is shown by Table II.

TABLE I

Mounting Height of Varicus Types of Signals

Type	Usual height of center of light from street surface
Tower	18 to 20 ft.
Pedestal	7 to 20 ft.
Post	8 to 15 ft.
Horizontal Bracket	12 to 18 ft.
Vertical Bracket	12 to 18 ft.
Mast-Arm	15 to 18 ft.
Suspension	12 to 18 ft.
Mushroom	8 in.

Operation of Signals

Although the practices followed in the operation of traffic signals are changing constantly as new and better methods are devised, those in use at the present time may be grouped under four general headings:

Individual Operation.—Under this method of operation each automatic signal is considered as a separate unit and its timing is based on conditions at the particular intersection. It is used at isolated locations where the signal has no effect on the movement of traffic at other intersections controlled by automatic signals. In such cases, however, the timing should be based upon the relative flow of traffic in the two intersecting streets.

Synchronized System.—Wherever the control of traffic of one intersection affects the movement of traffic at another controlled intersection, some plan of co-ordination should be developed. Otherwise, unnecessary delays and crowding will result. Furthermore, the vehicles released at one intersection may just reach the next controlled one as the red light flashes on, thus forcing a stoppage.

The simplest method of co-ordination is the Synchronized Plan used originally in New York City. In accordance with it a number of signals are operated together as a unit. For instance, all the signals in the system will show red in the same direction at the same time and will be changed simultaneously. This permits of a north and south movement throughout the controlled section, while east and west movement is halted. Under the Synchronized System the relative quantity of traffic on intersecting streets at a given intersection cannot govern the timing of the individual signal, but the relative flow of north and south traffic as compared with that of the east and west traffic throughout the area must be used to govern the timing of the entire system. Provision should be made for breaking the Synchronized System into small units for emergency operation, and a hand operating device should be installed at each signal.

Progressive System.—When the Synchronized System is used all vehicles are forced to stop at least once during the change of signals. The Progressive System, sometimes called the "Wave," "Platoon" or "Staggered" System, was designed to overcome as far as possible this necessity for stopping. In accordance with it, all signals in the system are changed simultaneously, but they are grouped as to the color displayed. For instance, on a given street the first two or three signals may show green, while the next group are red, and so on throughout the controlled section of the street. The timing of the signals is so arranged that vehicles once entering the controlled area and traveling at a predetermined safe speed will reach a red light as it is changing to green and thus avoid the necessity of stopping, although sufficient interval has been provided for cross-travel on intersecting streets.

This plan permits of approximately continuous movement of traffic in both directions while at the same time it discourages speeding, as the speeder would be halted at nearly every intersection. The Progressive System is most effective on a wide thoroughfare where blocks are of equal length. Where they are not, a varying number of blocks may be grouped in such a way that the driving distance of each group is approximately the same. Where the area of a city to be controlled consists of a rectangular layout of streets with blocks of nearly equal lengths in a given direction, the Progressive System may be applied to the entire area. Here, as in the Synchronized System, provision should be made for emergency grouping and hand operation.

Co-ordinated System.—No consideration can be given under the Progressive System (wave, platoon or staggered) to the relative flow of traffic, either in individual intersecting streets or by directions, considering the entire controlled area as a unit. On the other hand, the period permitted for the red and green lights must be of equal duration. In cities where a predominance of traffic is in one direction this works a rather serious handicap, particularly if the system covers more than one through street. The co-ordinated system being successfully used in the Loop District of Chicago was designed to overcome this difficulty and provide a system which as far as practicable would take into account local conditions at intersections and time of travel between the same. Each signal may be changed at a different time, but unlike the individual method of operation, the changing of all signals is co-ordinated. Similar to the Progressive Plan, it provides for an approximately continuous movement of vehicles not exceeding the speed limit.

The co-ordinated method of traffic control is one of the most flexible systems yet devised. This method, with the auxiliary apparatus required, may, however, most satisfactorily serve special traffic conditions. The co-ordination of traffic may be secured in two ways, either by central control or by the use of individual motors of a synchronous type.

In operating it a given intersection is selected as a starting point and the proper timing of its signal is determined. The next intersection is considered in like manner but its cycle of changes is started a sufficient time after the start of the cycle at the basic intersection to permit vehicles to move from one to the other,

TABLE II

Location of Various Types of Signals

Tower	Pedestal	Post	Horizontal or Vertical Bracket or Mast-Arm Suspension	Suspension	Mushroom
Center of street intersection. Throat of street.	Center of street intersection. Throat of street. Isles of safety.	Center of street intersection. Throat of street. On the curb at street corner. Isles of safety. Dead end of street. Right side of road leading to curve.	On the curb at street corners attached to special posts. Street lighting posts. Trolley poles, etc. Also at right hand side of road leading to a curve.	Center of street intersection. Throat of street. (Equipped with steel cable and automatic lowering device.)	Center of street intersection. Throat of street. On surface of roadway for fixing restricted zones as at squares, safety and loading points, etc.

considering speed limitations and conditions of travel. The same plan is then applied to each intersection of the selected street within the controlled area and is subsequently applied to parallel streets, taking into full consideration the result and effect on cross streets. Certain allowances will be found necessary in order to co-ordinate the system for the entire area, but the resulting ease of movement in the section as a whole should offset the disadvantages of these particular allowances.

The time permitted for a complete change of signals must be equal for all control points, but with the operating mechanism provided, this period may be altered for the system as a whole from time to time during the day as conditions warrant. Furthermore, the percentage of the period allowed for north and south traffic to that for east and west traffic may be altered at each individual intersection to satisfy changing conditions.

AMERICAN STEEL & WIRE COMPANY

Sales Offices Listed on Pages 92 and 166

Banner R. R. Rail Section and Ideal U Steel Posts for Snow Fencing, Road Signs and Highway Fences

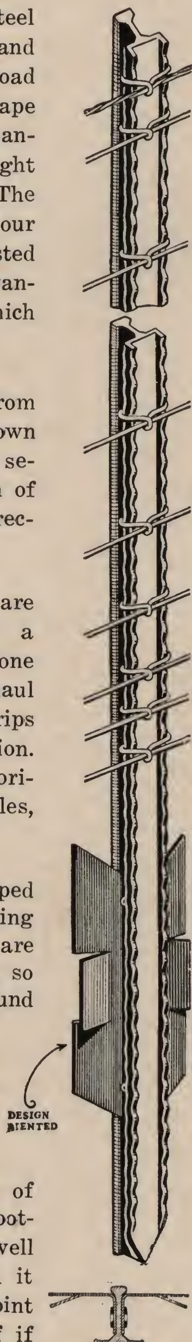
Products: BANNER R. R. RAIL SECTION AND IDEAL U SHAPE STEEL POSTS.

We offer the trade two types of steel posts for snow fencing, road signs and highway fence—the Banner or Railroad rail section Post and the Ideal U Shape Post illustrated on this page. The Banner Post is made in one size or weight of section, but in various lengths. The Ideal U Shape Post is made in four weights and in various lengths, as listed below. Both styles have their advantages, according to the way in which they are to be used.

Strength: These posts are made from ore to the finished product in our own mills and on account of the specially selected steel and scientific distribution of metal, offer unusual strength in all directions.

Economy: Ideal and Banner Posts are very economical. They pack well; a bundle of five is as easily handled as one large wood post, so it costs less to haul and distribute them—fewer return trips to railroad depot or supply station. These posts are easy to drive, no laborious and expensive digging of post holes, setting or tamping.

Anchor Plates: These posts are equipped with unusually large patented slit wing anchor plates, size 3¼"x 9¼", and are firmly riveted lengthwise to the post so that the posts retain all of their ground facing surface. The slit wings pack the dirt against the sides of the posts, and as they cut separate slots, lock the post in the ground as driven. Anchor plate is not damaged in driving. Posts can be used over again in other places when desired. The top of anchor plate is placed 18" above the bottom end of post so that it will be well below surface when driven, although it can be raised or lowered to any point desired on special orders, or left off if not wanted.



Banner Post

Ground Plate: For Snow Fence purposes, Ideal U Posts can be equipped, if desired, with a large triangular shaped ground plate. The top of this plate is usually 30 inches from the bottom end of the post, although it can be placed at any point wanted. This ground plate is made of heavy steel, size 8¾x3¾x2" and is firmly riveted to the back of the post.

Driving: Banner and Ideal Posts can be easily driven in any kind of soil with an ordinary steel sledge or the National Post Driver—no laborious digging of post holes.

Finish: Banner and Ideal Posts are finished with a heavy coat of special steel paint, having unusually high preservative and lasting qualities. The paint is baked on under a high temperature and will give many years of satisfactory service. Banner Posts are painted Battleship Gray; Ideal Posts are painted Willow Green. Galvanized Posts can be furnished when wanted.

Clamps: Both Banner and Ideal U Posts have both edges of the face rolled into a series of lugs, which not only add strength to the post but provide two continuous rows of notches spaced ¾" apart to hold fence clamps. Drop loop clamps do not bind the fence wires, as the wires are carried in a loop, which allows plenty of side movement to equalize strains. The clamps are easily attached with a hammer and hold securely. Special wire staple shaped clamps can be furnished, if desired, for attaching wood slat snow fencing as described on next page.

SPECIFICATIONS

Sizes and Weights (Including Anchors)

Length of Post in Feet	IDEAL U POSTS				Banner Post Rail-road Rail Section
	Spec. A Width 2⅜ in., lbs.	Spec. B Width 2⅜ in., lbs.	Spec. C Width 2⅜ in., lbs.	Spec. D Width 1$\frac{15}{16}$ in., lbs.	Width 1⅜ in., lbs.
5 ft.	13.76	10.76	9.76	7.32	7.32
5½ ft.	15.06	11.76	10.66	7.99	7.99
6 ft.	16.36	12.76	11.56	8.65	8.65
6½ ft.	17.66	13.76	12.46	9.32	9.32
7 ft.	18.96	14.76	13.36	9.98	9.98
7½ ft.	20.26	15.76	14.26	10.65	10.65
8 ft.	21.56	16.76	15.16	11.31	11.31

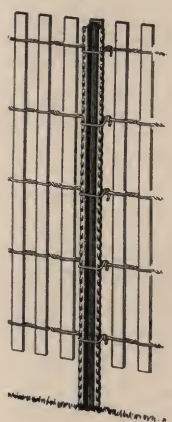
9, 10 and 11 foot posts furnished if desired.

Ideal U Post

Banner and Ideal U Steel Posts for Snow Fence and Road Signs

See Opposite Page for Post Specifications

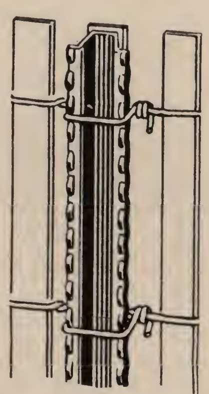
Steel Posts for Snow Fence: The illustrations show the ordinary 4′ wood slat snow fence attached to Steel Posts. The posts are usually spaced about 10′ apart, and the fence is attached with special wire staples or clamps. The fence is usually stretched between the end posts, and line posts then driven in correct position to come directly behind one of the slats if wire staple clamp is used, or behind space between slats if loop clamp is used.



Wood Slat Snow Fence on Ideal U Steel Posts

Ideal steel Posts can be furnished in four weights from Specifications D 1.33 lbs. per foot to the very heavy section, Specifications A 2.60 lbs. per foot as listed on opposite page. Specifications A, B, and C are especially made for snow fence use, and are punched with 9/16″ hole, one inch from top, so that tie wires can be used when erecting fence if desired. Ideal posts can be furnished with or without anchor plates, or with a ground plate if so specified.

Banner steel posts have been used extensively with wood slat snow fence, and are very popular. The fence can be attached with our loop clamp, and a hole can be punched in stem near top for tie wires. Posts can be furnished with or without anchor plates.



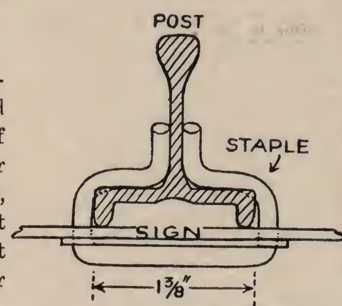
Staple method of fastening wood slat snow fence to Ideal U Posts

Sign Fastened to Banner Post with Heavy Staples

Staple Method of Attaching Signs: Road signs can be easily attached to Banner Posts by the staple method. Heavy No. 6 galvanized wire staples are furnished to go through the sign and they can be easily and effectively clinched behind the face of the post by a special tool, as illustrated. Two staples are sufficient for the ordinary type of shield marker. Galvanized metal washers are furnished to go under the staple and over the face of the sign to protect the enamel. The staple method is very economical—no bolts needed. Signs cannot be tampered with. Additional signs, such as detour markers, etc., can be easily attached at any point on the post; no holes necessary.

Banner Sign Post Tool

Wind Vibration Prevented: The fluted edges on both sides of the face of the Banner Post, spaced 1⅜″ apart, or the Ideal U Post spaced 1 15/16″ apart in Specifications D, or 2⅜″ apart in Specifications A, B and C, give wide support for signs and effectively prevent wind vibration.

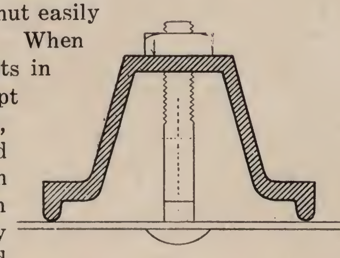


Section Through Banner Post

Life of Signs Increased: The fluted edges on the Banner and Ideal U shaped Posts keep the back of the sign properly ventilated, preventing the accumulation of dirt and moisture, increasing the life of the signs. Signs often rust out from the back when bolted to a flat surface.

Sign Bolted to Ideal U Post

Bolting Signs to Posts: For those who prefer to attach signs with bolts, the Ideal U Posts offer a splendid support for signs. Holes can be punched in the back at any point desired. The signs can be placed across the wide face of the post and the bolt drawn through between the side walls and the nut easily attached at the back. When signs are bolted to posts in this way, they are kept under a slight tension, thus preventing wind vibration, which often causes nuts to loosen and fall off, especially when they are fastened to a flat surface.



Cross Section Ideal U Post and Sign

Highway Cost Keeping*

By James J. Tobin and A. R. Losh, U. S. Engineer Economists
Reviewed by Halbert P. Gillette

The term "cost," as generally interpreted and as used in this bulletin, is the summation of expenditures expressed in terms of money involved to acquire or produce a utility or to perform a service.

The cost of every unit of product, whether it be a square yard of road surface maintained, or a cubic yard of concrete which is a part of a bridge or culvert, is composed of four basic elements of expense, namely:

(1) The cost of labor.
(2) The cost of materials.
(3) The cost of service of plant and equipment.
(4) The cost of general expense or overhead.

Labor: The costs of labor are divided into two classes; first, direct labor cost; and, second, indirect labor cost. All labor chargeable against the product which can be designated as directly expended on it is called direct labor. All labor chargeable against production and not directly expended on the product is called indirect labor. For example, the cost of men using picks and shovels on excavation who are directly expending their efforts on that piece of work is a direct labor charge. A superintendent in charge of a road job is not directly expending labor on excavation, but is engaged in directing the prosecution of all kinds of work and his expense is an indirect labor charge, chargeable pro rata against the production of all the work units he may be supervising. Other examples of indirect labor are the services of watchmen, timekeepers, and water boys.

Materials Materials also are divided into two similar classes—direct and indirect. All materials entering the product as an integral part of its composition are called direct materials. All materials chargeable against the production but which do not enter directly into the product as an integral part of it are called indirect or expense materials or sometimes supplies. The cement, stone, and sand that are mixed together to form the concrete of which a concrete road is constructed are all direct materials, but the oil used for lubricating and the gasoline for operating the mixer in which these materials are prepared for use are indirect materials or supplies. It is easy to charge direct material cost, but often it is very difficult to charge to each product its correct share of indirect material cost.

Small, or hand, tools not used as a part of some plant unit and which have such a short period of usefulness that they are seldom used on more than one job, usually are considered supplies and therefore are part of the indirect materials charged to the work.

Plant and Equipment: "Plant" includes such physical property used on the work as land, structures, machinery, live stock, and tools of a more permanent character than those referred to as supplies. "Equipment" is a less inclusive term and is interpreted generally to mean the smaller and especially the movable plant units. The cost of the service of "plant" can be charged most readily in the form of a daily rental against the work upon which it is used. This rental should be charged whether the equipment be owned by the operating organization or leased from other owners. It consists of "operating charges," which are—

(*a*) The expense of operation,
(*b*) The average cost of repairs,
(*c*) Charges for the time spent in idleness,

and "fixed charges," which are—

(*d*) Charges for depreciation,
(*e*) Interest,
(*f*) Taxes,
(*g*) Insurance.

The Expense of Operation: This includes the wages of operators and helpers and the cost of supplies during the periods of operation. Usually these are charged directly against the work done and not included in the plant rental. It is only necessary that they be charged in one place or the other, and it is important to specify what is included in rental when leasing equipment.

The Average Cost of Repairs: There is a difference of opinion among cost accountants as to how repairs and renewals to plant should be charged. One view is that renewals may be of such a nature that the useful life of the machine has been increased and therefore the expense of such renewals should be looked upon as an offset to depreciation. Another view is that there is no difference between repairs and renewals, except in degree, and that they all should be considered in the same light; i. e., independent of depreciation charges. It appears that the latter consideration permits simpler accounting and does not rely so much upon individual judgment as to whether the expenditure is for repairs or for renewals.

After a machine has been rebuilt or repaired extensively with the intention of increasing its serviceable life, it should be considered as a piece of new equipment valued at its depreciated value, plus the cost of renewals. This necessitates the computing of a new rate of depreciation on the basis of the new value and assumed new useful life.

The approximate average cost of repairs, including extraordinary repairs, often can be arrived at by casting up old accounts and finding what a similar piece of machinery used on similar work has cost for repairs over a term of years.

Charges for Time Spent in Idleness: To arrive at a fair and equitable daily charge for rental some allowance must be made for time spent in idleness, because on these days the fixed charges still are continuing and certain supplies are necessary even though the machine be not in operation. The usual way of arriving at the charge for lost time through idleness is to bring together all of the charges for a year and divide them by the number of days the machine actually was in use. By dividing the sum total of expense by the number of days the machine was available for use even though no work existed on which it could be used, the result would be a daily rental with no allowance for lost time. The difference between these two rentals will show what a considerable factor in the fixed charges this item of lost time may become. In all contracts or agreements on rental of equipment care should be taken to specify whether the rental is "per day" or "per day of service."

Charges for Depreciation: Equipment is consumed in production just as truly as material. This loss is called natural depreciation. Depreciation may be either natural or functional. "All equipment progresses steadily toward the scrap pile, starting the date it is purchased, and while its progress may be delayed it can not be prevented by repairs."[1] It is as much an expense on a steam roller as the cost of fuel burned in the fire box. In the case of fuel the expense is immediate; in the case of depreciation the expense is extended over a period of time. Functional depreciation is loss due to the obsolescence or inadequacy of equipment.

COMPARISON OF DEPRECIATION FORMULAS

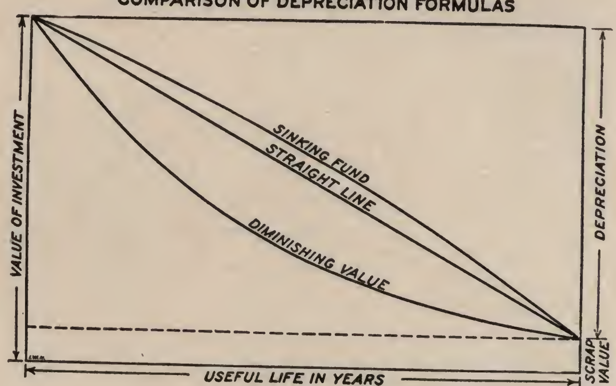


Fig. 1

There is no doubt in the minds of cost accountants that depreciation of plant and equipment should be included as a charge against operation, but there is considerable difference of opinion as to how depreciation should be computed.

Three factors determine in all cases what the depreciation should be: First, the original cost; second, the length of useful life; and third, the scrap value of the machine when it no longer can be used for the purpose for which it was purchased, or the salvage value, if it is to be considered as a "second-hand" piece of equipment. Knowing these factors, the problem resolves itself into how to divide the difference between the original cost and the scrap or salvage value (called total depreciation or wearing value) over the length of the useful life of the machine. A number of formulas have been devised for computing decrease in value or depreciation. Fish, in his textbook on "Engineering Economics," explains five such formulas. Three of the more commonly used are the straight line, the declining balance, and the sinking fund.

The first is recommended as the simplest and perhaps best method for road work. By this method the total depreciation is divided by the number of years of useful life and the quotient charged off as a yearly depreciation. This is called the straight-line method, and its greatest advantage is its extreme simplicity.

The second method, a modification of the straight-line method, is called the declining balance method. It is based on the theory that during the earlier years of the life of any machine the repairs are smallest, and therefore to arrive at a constant charge for repairs and depreciation, the depreciation must be heaviest in the earlier years of the life of the machine and lightest in the last. The plan, therefore, is to charge off a fixed percentage annually from the net value of the machine. This gives a diminishing

* A bulletin issued by the U. S. Department of Agriculture as a contribution from the Office of Public Roads and Rural Engineering (now U. S. Bureau of Public Roads).

[1] Modern Accounting, by H. R. Hatfield.

annual charge for depreciation. In the comparative table this annual rate is about 30 per cent. This is determined by the formula $r = 1 - \sqrt[n]{\frac{v_2}{v_1}}$ in which r is the percentage of diminishing value, n the life of the equipment in years, v_1 the original value, and v_2 the scrap value.

The third method is called the sinking-fund method. It is based on the assumption that the depreciation on a structure at any time is equal to the accumulations of a sinking fund established for renewal at the end of its useful life. The depreciated value plus this sinking fund (actual or imaginary) at any period equals the original cost.

It should be observed that none of these formulas takes into consideration interest on investment, output, cost of operation, or maintenance charges. Figure 1 gives a graphic comparison of the above formulas.

The following table is a comparison of the annual depreciation on a $600 machine that has an assumed useful life of five years. It also is assumed that at the end of this period it will have a scrap value of $100. The annual depreciation is computed by the three formulas described:

Comparison of Three Methods of Computing Depreciation

Years	Straight-line method.	Diminishing-ing-value method.	Sinking-fund method, 6 per cent interest.
First	$100	$180.72	$ 88.70
Second	100	126.28	94.02
Third	100	88.25	99.66
Fourth	100	61.67	105.64
Fifth	100	43.08	119.98
Total	$500	$500.00	$500.00

The theory of natural depreciation, epitomized, is that all equipment, even if kept in the best of repair, in time will reach a state where repairs no longer are sufficient to keep it in economical working condition and the entire machine must be renewed. The fund created by the depreciation charges is intended to supply the money to purchase a new machine to take the place of the one expended, or to retire the original investment in case the machine no longer is needed.

Any of the depreciation formulas is satisfactory in determining rental charges, provided the assumed life of the machine be approximately correct. As the assumption of the useful life of the machine may be the source of considerable error, there seems to be little argument for the finer calculations as to the methods of distributing the depreciation.

It will be found convenient in computing depreciation to group elements of the plant having approximately the same serviceable life. This will have the advantages of requiring fewer accounts and tending to equalize high and low assumed machine life.

Repairs and renewals are charges due to breakage or the wearing out of expendable parts of equipment. It is obviously incorrect to charge to repairs or renewals any improvements or betterments added to any piece of equipment. When such improvements have been made the cost should be added to the present value of the machine and a new depreciation computed upon this new value. An example of such a case would be the addition of a conveyor to an old stone crusher for the purpose of doing away with shovelers. The improvement is not a repair of any broken parts or a renewal of any part worn out by the continual use of the machine; it is a new feature which adds to the value of the crusher. A rebuilt second-hand machine may be considered in the same light.

Interest, Taxes, and Insurance: Interest should be charged on the investment at the rate paid or the prevailing rate, where there is no indebtedness.

Taxes, as paid, should be charged in the rental rate.

Insurance should be charged either as paid or at the prevailing rates if the organization carries its own risk.

Fixed charges are discussed further on.

General Expenses: The fourth element of cost is general expense. It often is called "overhead" or "burden," terms derived from factory cost keeping, the use of which in highway-cost keeping is not recommended.

General expense includes all charges that can not be connected directly with the cost of labor, material, and plant. For convenience in accounting and for the purpose of securing a desirable division of road cost, general expense will be considered as divided into two classes. One will be referred to as "engineering and supervision" and will include those items of inspection and engineering which can be charged directly to the project. The other class will be referred to as "administration expense" and include those expenditures incurred in conducting all the activities of the department which are so general in character that they are not assignable directly to any particular project.

The desirability of separating the project cost of engineering and supervision from administration cost and unit costs will be apparent after a little consideration. The work of the engineer in preparing the plans and specifications affects labor and material costs only in the kinds and amounts that may be required and not at all in the efficiency of their expenditure. By carefully worked out profiles and cross-sections an engineer may reduce the yardage of excavation required, but such planning may not reduce the cost per unit of excavation. To secure efficiency in operations is the function of the superintendent or the foreman who is responsible for the cost of such operations. If engineering and supervision cost is incorporated in unit cost, an element is included over which the foreman or superintendent has no control, and his efficiency is obscured thereby. If, on the other hand, engineering and supervision cost is included in the charge for administration, it is placed in a class of expenditures over which the engineer has little or no control.

Highway administrative organizations are prescribed largely by statute and the attendant costs necessarily are dependent, in a large measure, upon the form of the organization, the various duties required, the methods of financing, and many other factors, all of which are conditions imposed by legislation. To include with these administrative costs the cost of project engineering and supervision would mean the loss of valuable comparable information on the efficiency of the divisions of an organization and one type of administrational organization with another.

Administration: Administration costs include such expenditures as salaries and expenses of the executive officers, legal services, maintenance of office, departmental engineering, investigations, experiments, clerical staff, fiscal operations, and miscellaneous fixed charges. These expenditures can not be allocated directly to any particular class of work or to individual projects.

Cost accountants have devised numerous ways of distributing general expenses to the various classes of work. Most of these, however, are not practicable in the distribution of such expenses on road work. Since indirect labor and indirect materials are distributed directly in the unit costs, and engineering and supervision are chargeable directly to projects, the remaining portion of what would be considered "burden" by factory cost accountants is comparatively small in proportion to the aggregate expenses. Any portion of general expense that can be assignable directly to a project should be charged against such project. The remainder should pe prorated over all the project expenditures for the period.

Engineering and Supervision: To engineering and supervision should be charged all expenditures for surveys, plans, specifications, estimates, tests, and all engineering inspection and supervision in the nature of oversight required to secure the proper execution of the work. Such expenditures can be charged directly to individual projects.

Fixed Charges: Fixed charges are those items of expense which go on practically unchanged irrespective of the activities of the organization. Those fixed charges which pertain to the production plant have been discussed in relation to plant and equipment. Certain fixed charges not immediately connected with production operations may best be considered as a part of general expense. Thus depreciation, interest, taxes, and insurance are elements of expense also in relation to the plant and equipment of the administrative organization, such as buildings, office and laboratory equipment, instruments, machines, and similar items.

In the practical application of cost keeping, fixed charges are considered only in so far as they aid in the determination of efficiency, and their inclusion as an item of cost is a question of accounting. Where fixed charges result from methods of financing rather than the methods of doing the work they belong to the field of bookkeeping and not cost keeping. Thus, where a county issues bonds for road improvement the interest is a fixed charge which must be paid and so increases the total outlay for the improvement but has no relation to the efficiency with which the work is executed, and is, therefore, a matter of bookkeeping and not cost keeping. Where two crews are engaged in excavation, one with power tools and the other with hand tools, fixed charges are of prime importance to the cost keeper for the purpose of determining efficiency and the cost of operation in each case.

Highway Cost Analysis

	Elements of cost.	Classes of cost.	Application of cost.	Product of cost.	Summary of cost.
Highway cost....	Labor cost...	Direct.....	Wages of laborers, mechanics, teamsters, etc.	Construction, maintenance, or reconstruction of road parts, right of way, grade and roadside, roadway, ditches, drains, bridges, and culverts, and supplementary parts.	By units, direct, as performed.
		Indirect...	Wages and expenses of superintendents, foremen, timekeepers, guards, watchmen, water boys, etc., lost labor days, labor expense.		
	Material cost...	Direct.....	Materials entering into product as integral parts.		
		Indirect...	Supplies, used but not as a part of product.		
	Plant and equipment service cost.	Operating.	Operation. Repairs. Idleness.		
		Fixed.....	Depreciation. Interest. Taxes. Insurance.		
	General expense cost.	Project: Engineering and supervision.	Salaries and expenses of engineers, field parties, draftsmen, inspectors, and clerks; office expenses, tests, and miscellaneous expenses for individual projects.	Plans, specifications, estimates, surveys, inspection, and direct supervision of work.	By project; upon completion may be apportioned to units.
		General: Administration.	Salaries and expenses of executive, engineering, legal, and clerical staffs; expense of office maintenance, experiments, investigations, and fiscal operations; miscellaneous fixed charges.	General direction, policy, oversight, planning, control, legal, and financial provisions.	On all operations over a period of time and apportioned to projects.

It is customary among contractors to include all fixed charges as a part of the expense of work, and therefore they appear in the unit prices of their itemized bids. In making up his estimates on unit prices to check against submitted bids, the engineer therefore should include among other fixed charges interest on capital invested in plant and on necessary operating capital, for materials, pay roll, and deferred payments.

Considerations of fixed charges are also important in the selecting of equipment and determining upon types of improvements. These considerations are, however, within the field of engineering economics and not cost keeping, although cost data have a most important part in the final determination.

Highway Cost Analysis: An analytical chart has been prepared to place before the reader in concise and convenient form a summary of the foregoing discussion of cost elements applied to road work, and to show the relation between the cost elements and the final cost of the project as expressed in totals and by units. The first column of the chart contains the four basic elements of cost. Opposite each element, in the second column, are the classes of expenditure, such as direct, indirect, etc. The third column shows in detail the specific application of the cost. Example, "for materials," "for labor," "superintendence," etc. The fourth column contains a tabulation of the class of product resulting from the cost outlay, such, for example, as construction, maintenance, right of way, etc. The fifth column contains the final cost and presents it by units by project, etc.

Units of Measurement: Care should be taken in selecting the units on which to collect cost data. Too many and varied units will make the system cumbersome and expensive, while too few may impair its value seriously. Furthermore, the units of measurement adopted for any cost-keeping system or project must be definite, expressive, readily obtainable, and familiar. Thus, for example, the ton and the cubic yard as applied to broken stone are definite units and afford a ready and accurate comparison but the square yard when applied to a finished macadam road is indefinite until additional information as to the depth of the material is available. Similarly, many units, such as wheelbarrow, wagon, truck, or carload, while often convenient units of count in the field, are indefinite and always should be reduced to definite comparable units, such as cubic yard or ton.

The units selected must, so far as possible, be expressive of definite operations. Thus, while in engineering construction the cubic yard is a very common unit upon which contract prices are based, it frequently is a very uncertain unit of performance, as it is a composite of other units. For example, in rock excavation there are involved the following operations: (1) Drilling, (2) blasting, (3) breaking large chunks, (4) loading into carts, wagons, cars, or the like, (5) transporting, (6) dumping.

The important item of drilling depends largely on the necessary spacing of the drill holes, which varies in the different kinds of rock and in different kinds of excavation. Clearly, then, the linear foot of drill holes is the unit for measuring the output of the drillers, and not the cubic yard. Transporting the rock is largely a function of distance; hence the unit of transportation cost should be the ton or yard carried 100 feet or 1 mile, and not the cubic yard without the factor of distance.

The units must be obtainable readily or the cost of collecting the necessary data will be too high. Thus, for example, to obtain the exact cubic yardage and the distance it was moved in preparing the subgrade for a macadam road with a road machine would be not only difficult, but expensive. Hence for this class of work the readily obtainable, though less definite, unit of the square yard usually is adopted.

That the full value of the cost-keeping system may be realized, the units in which the data are expressed must be familiar to those charged with their collection as well as to those who are to profit from their use. Thus, the cubic meter is as definite a unit for measuring earthwork and generally as readily obtainable as the cubic yard, but to the average roadman it has little or no meaning until translated into the terms in which he is accustomed to think. If any one of two or more units otherwise would answer equally well, the one most familiar and generally used always should be adopted.

There are many units so closely related to the desired unit of measurement that with very little computation they can be transformed into the desired unit. For example, the knowledge of the number of bags or barrels of cement used and the proportion of the mixture of the concrete are functions which at once determine the amount of sand and stone used.

COST KEEPING FOR HIGHWAY WORK

Essentials of a Cost System: Certain fundamental principles must be followed to make any cost system successful. This applies to road costs as well as to factory costs. Any cost-keeping system to be successful must be (1) reliable, (2) simple, (3) immediate, (4) flexible, and (5) relatively inexpensive.

(1) Reliability is of paramount importance. If the data collected are not reliable, all records based upon them of course will be misleading and the results dangerous. Accuracy is desirable, but this need not be carried beyond the practical limits adopted for measuring the units of materials expended and the units of work accomplished.

(2) If simplicity be not maintained the purpose of the system will be defeated. Involved and complex forms are confusing to the recording officials, difficult to compile for study and analysis, and apt to be inaccurate and a useless expense.

(3) To be effective, the cost records must be susceptible of immediate analysis and must reach the officials responsible for the economic progress of the work in time to be of use. If a week or 10 days must elapse before wasteful methods and incompetency are discovered the information is past history and it may be too late to try other methods which might rectify the detrimental condition.

(4) Flexibility is very desirable. The system must be elastic enough to provide for the recording of all classes of work, irrespective of the size of the project, without any material change in the prescribed forms.

(5) Finally, the system must be relatively inexpensive. The cost of determining cost must be reduced to a minimum. If expense of obtaining cost records to point out the way to efficiency is not much below the saving effected, they have no just claim to a place in any plan of management.

Classification of Expenditures: The first problem in developing a cost-keeping system for highway work is to devise a general classification of expenditures that will conform to accounts appearing upon the ledger of the organization; that is, at the outset the cost keeper's records must tie into the bookkeeper's accounts. The ledger, it is well to recall, contains only as debits the funds received or appropriated and as credits the payments made from those various funds summarized from a record which carries the distribution of these expenditures according to subheadings or primary accounts. It is usual to classify accounts as far as possible by departments, or with respect to certain functions for which funds are provided. Such a classification of accounts provides the first division for the cost keeper. This division gives what usually are known as the general accounts. Numbers or letters are used to represent these accounts, and in these letters or symbols we have the beginning of a code for cost keeping. The following classification and corresponding letters show a deparmental division of accounts and a letter code suitable for highway work:

GENERAL ACCOUNTS

C. Construction.—M. Maintenance.—R. Reconstruction.—P. Plant.—A. Administration.

The first three of these, it will be observed, have to do with certain road operations. It will be found upon analysis that they consist of the operations necessary to produce or preserve road parts. A subdivision of these general accounts produces what are called the primary accounts. Such a division is shown below. The accompanying numbers give a development of the cost-keeping code:

C, M, and R. Construction, Maintenance and Reconstruction

00 to 09. Right of way.
10 to 19. Grade and roadside.
20 to 29. Roadway.
30 to 39. Ditches and drains.
40 to 49. Bridges and culverts.
50 to 59 Supplementary parts.
60 to 69. Engineering and supervision.

P. Plant

70 to 79. Plant accounts.

A. Administration

80 to 99. Administration accounts.

The numbers preceding the primary account give the range of class numbers for the final cost-keeping code. Thus 30 to 39 are the inclusive numbers for class costs of ditches and drains. This first division of the general accounts would serve very satisfactorily for a simple cost-keeping system. In such case the first set of numbers could be omitted and ditches and drains would be represented by 39 instead of the range of numbers from 30 to 39.

To obtain a system of class numbers for more detailed costs these primary accounts are further expanded as shown in the following table:

PRIMARY ACCOUNTS AND CLASS CODE

C, M, and R. Construction, Maintenance, and Reconstruction

Right of Way

00 Preliminaries.
01 Right-of-way surveys.
02 Right-of-way plans.
03 Real estate.
04 Damages.
09 Miscellaneous.

Grade and Roadside

10 Cuts and embankments.
11 Shoulders.
12 Berms and slopes.
13 Trees, shrubs, grass, etc.
19 Miscellaneous.

Roadway

20 Subgrade.
21 V drains.
22 Sub-base.
23 Base course.
24 Intermediate course.
25 Binder course.
26 Cushion course.
27 Top course.
28 Surface.
29 Miscellaneous.

Ditches and Drains

30 Ditches and gutters.
31 Ditches and gutters, paved.
32 Blind drains.
33 Tile drains.
34 Catch basins.
35 Drainage channels.
39 Miscellaneous.

Bridges and Culverts

40 Foundations.
41 Abutments.
42 Piers and bents.
43 Superstructures.
44 Box culverts.
45 Pipe culverts.
49 Miscellaneous.

Supplementary Parts

50 Signs and sign posts.
51 Monuments.
52 Guard rails.
53 Curbs.
54 Retaining walls and parapets.
55 Riprap and revetments.
56 Roadside treatment.
59 Miscellaneous.

Engineering and Supervision

60 Location and relocation surveys.
61 Surveys (for operations).
62 Plans.
63 Specifications and contract preparation.
64 Estimates.
65 Expense of awards.
66 Office expenses, engineering.
67 Supervisory engineering.
68 Inspection and tests.
69 Miscellaneous.

PRIMARY ACCOUNTS AND CLASS CODE—Continued

P. Plant and Equipment

70 Buildings, fixtures, and grounds.
71 Quarries, pits, material yards, etc.
72 Power tools and equipment.
73 Hand tools and equipment.
74 Livestock and vehicles.
75 Camp equipment.
76 Camp buildings and shelters.
77 Storage and transportation.
79 Miscellaneous.

} Primary Accounts.

A. Administration

80 Executive.
90 Maintenance of office.
92 Legal.
94 Clerical.
95 Fiscal.
97 Engineering, departmental.
99 Miscellaneous.

} Primary Accounts.

(Note.—It will be observed that no divisions beyond primary accounts have been provided under Plant and Administration. These can be expanded further to meet the requirements of the organization.)

Operation Code: The next step is to develop a series of operations and a corresponding code which will include all the operations performed by the various departments to construct and maintain the works under their supervision. This may be accomplished in either of two ways. One is to list with each class of work all the operations that are performed under it. The other is to designate an operation by symbol and prefix this symbol with a class symbol, designating the class of work. By the first method such an operation as "rolling" would be listed under each roadway part and for both construction and maintenance. In the latter method, which is followed in this bulletin, "rolling" occurs only once in the operation code and the class code symbol is prefixed to give it the distinguishing classification. Thus any work can be indicated by combining a class code symbol and an operation code symbol.

The operation code consists of a list of descriptive phrases arranged alphabetically and designated by consecutive numbers following a dash or decimal point. This dash or decimal shows the linking together of the classification and operation codes. The operation code must include all operations necessary to be performed and the phrases must be limited to a single interpretation. The divisions of the primary and general accounts given previously form the class code. As these class code numbers represent road parts or departments of the organization, an accumulation of a number of operations for any particular road part or department is effected readily by grouping all of those having the same class number. Below is given a typical operation series for the general operations of construction, reconstruction, and maintenance of highways. A similar code could be devised for other operations.

The Operation Code

–00 Assembling.
–01 Back filling.
–02 Blacksmithing.
–03 Blasting.
–04 Building.
–05 Building false work.
–06 Cleaning.
–07 Clearing.
–08 Clearing and grubbing.
–09 Cofferdamming.
–10 Cribbing.
–11 Curing concrete.
–12 Crushing.
–13 Dragging.
–14 Drilling.
–15 Drilling and blasting.
–16 Excavating borrow.
–17 Excavating common.
–18 Excavating earth.
–19 Excavating loose rock.
–20 Excavating solid rock.
–21 Excavating wet earth.
–22 Filling ruts.
–23 Filling washouts.
–24 Finishing.
–25 Forming.
–26 General.
–27 Grouting.
–28 Grubbing.
–29 Guarding.
–30 Harrowing.
–31 Hauling.
–32 Heating bituminous materials.
–33 Heating materials.
–34 Laying.
–35 Loading.
–36 Loading and hauling.
–37 Loosening.
–38 Mixing.
–39 Mixing and placing.
–40 Moving.
–41 Operating.
–42 Oiling.
–43 Painting.
–44 Patroling.
–45 Pile driving.
–46 Placing materials.
–47 Placing steel.
–48 Planting.
–49 Plumbing.
–50 Plowing.
–51 Pumping.
–52 Quarrying.
–53 Removing snow.
–54 Repairing.
–55 Riveting.
–56 Rolling.
–57 Scarifying.
–58 Screening.
–59 Shaping.
–60 Spreading bituminous materials.
–61 Spreading materials.
–62 Spreading screenings, sand, or chips.
–63 Sprinkling.
–64 Stripping.
–65 Tamping.
–66 Trimming.
–67 Washing.
–68 Washing and screening.
–69 Wasting materials.
–70 Water-proofing.
–71 Working on joints.
–72 Wrecking.

Method of Obtaining Class and Operation Number From Code: To procure a code number for any unit of work it is first decided what class of work is under consideration, and a number is selected from the class table. Then the specific operation is sought for in the second, or operation, table. The two are joined together with a hyphen or dash. The code letter of the department then may be prefixed to the first number and the classification symbol is complete.

If it be desired to know the code numbers to be used for recording the labor of a man mixing concrete for use as a road top course the class number for a road top course first is looked up in the class code. This number is found to be 27; then the operation "mixing" is taken from the operation code and found to be 38. Joining the two together with a dash produces the full code symbol 27–38. The letter "C" prefixed would indicate construction work, while the letter "M" would indicate a maintenance operation.

Usually no classification letter will be used, but instead the capital letter "C", "M", or "R" will be shown on the recording form. If it be desired to know what code symbol to use in order to indicate properly the time of a man spreading bituminous material on a road for maintenance purposes, the letter "M" is set down first to show that the work is that of maintenance. From the class code the number for a surface is found to be 28. Preceding this number with a capital letter "M" gives M–28, which shows that maintenance work has been done on a road surface. Then there is selected from the operation code the number for spreading bitumen, which is found to be 60. The code symbol for maintenance work of spreading bitumen on a road surface then will be M–28–60.

Use of Code in Operations: In actual use the cost keeper generally would obtain his data from the timekeeper, who would be charged with keeping time and costs. A code for use of the timekeeper would be prepared from the class and operation codes, which would have the advantage of being abbreviated and also properly arranged for the cost keeper's needs. Below is shown such a code, which was used on work where costs of the principal operations were desired, and also the expanded code, which was used where it was desired to make a more detailed study of operations for the purposes of efficiency.

Timekeeper's Code

Abbreviated

(1)
19–17 Grading—rough.

(2)
20–59 Grading—fine.

(3)
23–26 Base course—general.

(4)
23–34 Base course—laying.

(5)
23–56 Base course—rolling.

(6)
23–62 Base course—spreading sand and chips.

(7)
27–36 Top course—loading and hauling.

(8)
27–34 Top course—laying.

(9)
27–60 Top course—spreading bitumen.

(10)
27–24 Top course—finishing.

Expanded

Grade and Roadside

11 Shoulders:
–56 Rolling.
–58 Shaping.

19 Miscellaneous:
–07 Clearing.
–16 Excavating borrow.
–17 Excavating common.
–19 Excavating loose rock.
–20 Excavating solid rock.
–28 Grubbing.
–31 Hauling.
–35 Loading.

Roadway

20 Subgrade:
–56 Rolling.
–59 Shaping.
–63 Sprinkling.

23 Base course:
–12 Crushing.
–31 Hauling.
–35 Loading.
–56 Rolling.
–61 Spreading materials.
–62 Spreading screenings, sand, and chips.
–63 Sprinkling.

27 Top course:
–31 Hauling.
–32 Heating bituminous materials.
–35 Loading.
–56 Rolling.
–60 Spreading bitumen.
–61 Spreading materials.
–62 Spreading screenings, sand, and chips.

23–06 Cleaning base.

The timekeeper had only ten code numbers for general use, but where detailed costs were desired in order to determine relative efficiency and to eliminate wasteful methods 28 code numbers were used.

Detail of Cost Accounts and Necessary Codes: The detail in which costs are recorded must be left to the judgment of the supervisor or engineer in charge of the work. Unnecessary refinements are not desirable, as they only increase the work of those who used the data. On the other hand, divisions that are too general and inclusive will prevent the study of results for the purpose of promoting efficiency. The use or final disposition of the data is the factor which should determine the necessary details.

For example, let it be assumed that a county engineer or superintendent desires costs on a brick road for the purpose of making reports on expenditures to the board of highway supervisors. In this case summary costs of completed parts probably would meet the requirements. The divisions would logically be the main divisions of the road and the costs would be collected by these divisions. This would provide the simplest division and consequently the simplest code, which for the case assumed would be as follows:

Cost Divisions

	Code.
Right of way	09
Grade and roadside (or grading)	19
Roadway (or surfacing)	29
Ditches and drains	39
Bridges and culverts	49
Supplementary parts	59
Engineering and supervision	69
Administration	99

The first and the last two of these divisions would be compiled from the office data so that the cost keeper would be concerned with only five divisions of field data.

The next advanced step that would be desirable in many cases would be the cost of major operations divided by road parts. This would give information suitable for the comparison of results with work of a like character or with unit prices or estimates.

Cost Divisions

Road Part.	Operation.	Code.
Right of way:		
Plans and surveys	General	01–26
Real estate		02–
Miscellaneous		09–
Grade and roadside:		
Miscellaneous	Clearing and grubbing	19–08
Miscellaneous	Excavation, common	19–17
Roadway		
Subgrade	Shaping	20–59
Base course	Laying	23–34
Top course	Laying	27–34
Ditches and drains:		
Paved gutter	Excavating, common	31–17
Paved gutter	Laying	31–34
Tile drains	Laying	33–34
Catch basins	General	33–26
Bridges and culverts:		
Foundations	Excavating, common	40–17
Foundations	Piling driving	40–45
Foundations	General	40–26
Abutments	General	41–26
Superstructures	General	43–26
Miscellaneous		49–
Supplementary parts:		
Signs and sign posts	General	50–26
Guard rails	General	52–26
Curbs	General	53–26
Miscellaneous		59–
Engineering and supervision:		
Supervisory engineering	General	67–26
Inspection	General	68–26
Miscellaneous		69–
Administration		
Engineering, departmental		97–
Miscellaneous		99–

For the purpose of obtaining costs in more detail than is given in the foregoing, both the class and operation codes are susceptible of further divisions. In the following, divisions are made of the example chosen which are as complete as will generally be practical to use for highway cost keeping except in those cases where efficiency studies are desired.

Cost Divisions

Road Part.	Operation.	Code.
Right of way:		
Preliminaries		00–
Right-of-way surveys	General	01–26
Right-of-way plans	General	02–26
Real estate		03–
Damages		04–
Miscellaneous		09–
Grade and roadside:		
Cuts and embankments	Excavating, common	10–17
Cuts and embankments	Excavating, borrow	10–16
Cuts and embankments	Drilling	10–14
Cuts and embankments	Blasting	10–03
Cuts and embankments	Loading	10–35
Cuts and embankments	Hauling	10–31
Cuts and embankments	Wasting materials	10–69
Cuts and embankments	Rolling	10–56
Shoulders	Rolling	11–56
Shoulders	Shaping	11–59
Berms and slopes	Trimming	12–66
Berms and slopes	Planting	12–48
Miscellaneous	Clearing	19–07
Miscellaneous	Grubbing	19–28
Miscellaneous	Blasting	19–03
Roadway:		
Subgrade	Shaping	20–59
Subgrade	Sprinkling	20–63
Subgrade	Rolling	20–56
Base course	Loading and hauling	22–36
Base course	Forming	22–25
Base course	Mixing	22–38
Base course	Placing	22–46
Base course	Shaping	22–59
Cushion course	General	26–26
Top course	Loading and hauling	27–36
Top course	Laying (brick)	27–34
Top course	Rolling (brick)	27–56

Roadway—Continued.

Road Part.	Operation.	Code.
Top course	Grouting	27–27
Top course	Curing concrete	27–11
Miscellaneous	Cleaning	29–06
Ditches and drains:		
Ditches and gutters	Excavating, common	30–17
Ditches and gutters paved	Forming	31–25
Ditches and gutters paved	Loading and hauling	31–36
Ditches and gutters paved	Mixing and placing	31–39
Ditches and gutters paved	Finishing	31–24
Ditches and gutters paved	Curing concrete	31–11
Tile drains	Excavating, common	33–17
Tile drains	Laying	33–34
Tile drains	Loading and hauling	33–36
Tile drains	Tamping	33–65
Tile drains	Back filling	33–01
Catch basins	Excavating, common	34–17
Catch basins	Loading and hauling	34–36
Catch basins	Laying (brick)	34–34
Bridges and culverts:		
Foundations	Cofferdaming	40–09
Foundations	Cribbing	40–10
Foundations	Excavating, common	40–17
Foundations	Excavating, wet	40–21
Foundations	Forming	40–25
Foundations	Loading and hauling	40–
Foundations	Pumping	40–51
Foundations	Pile driving	40–45
Foundations	Mixing and placing (concrete)	40–39
Foundations	Back filling	41–01
Abutments	Loading and hauling	41–36
Abutments	Laying (masonry)	41–34
Abutments	Pumping	41–51
Abutments	Quarrying (masonry)	41–52
Piers and bents	(Same operations as abutments)	42–
Superstructures	Blacksmithing	43–02
Superstructures	Building false work	43–05
Superstructures	Curing concrete	43–11
Superstructures	Finishing	43–24
Superstructures	Forming	43–25
Superstructures	Loading and hauling	43–36
Superstructures	Mixing and placing (concrete)	43–39
Superstructures	Placing steel	43–47
Box culverts	Excavating, common	44–17
Box culverts	Loading and hauling	44–36
Box culverts	Forming	44–25
Box culverts	Mixing and placing	44–39
Box culverts	Curing concrete	44–11
Pipe culverts	Back filling	45–01
Pipe culverts	Excavating, common	45–17
Pipe culverts	Forming (headwalls)	45–25
Pipe culverts	Laying (pipe)	45–34
Pipe culverts	Loading and hauling	45–36
Pipe culverts	Mixing and placing	45–39
Miscellaneous	Cleaning	49–06
Supplementary parts:		
Signs and signposts	Building	50–04
Signs and signposts	Loading and hauling	50–36
Signs and signposts	Painting	50–43
Monuments	General	51–26
Guardrails	Building	52–04
Guardrails	Loading and hauling	52–36
Guardrails	Painting	52–43
Curbs	Back filling	53–01
Curbs	Curing concrete	53–11
Curbs	Excavating, common	53–17
Curbs	Finishing	53–24
Curbs	Forming	53–25
Curbs	Mixing and placing	53–39
Riprap and revetments	Loading and hauling	55–46
Riprap and revetments	Placing materials	55–46
Roadside treatment	Clearing	56–07
Roadside treatment	Loading and hauling	56–36
Roadside treatment	Planting	56–48
Roadside treatment	Painting	56–43
Engineering and supervision:		
Location and relocation surveys	General	60–26
Surveys for operations	General	61–26
Plans	General	62–26
Specifications and contracts	General	63–26
Estimates	General	64–26
Expense of awards	General	65–26
Office expenses engineering	General	66–26
Supervisory engineering	General	67–26
Inspection	General	68–26
Miscellaneous		69–
Plant and equipment:		
Quarries, pits, etc.	General	71–26
Camp buildings and shelters	General	76–26
Storage and transportation	General	77–26
Miscellaneous	Assembling	79–00
Miscellaneous		79–
Administration:		
Engineering		97–
Miscellaneous		99–

Recording Forms.—Standard forms, to record the daily expenditures of labor, materials, and plant service, should be prepared for the use of the timekeepers or foremen responsible for reports. The use of nondescript forms or blank books should not be permitted, as such practice will result in unreliable data, often estimated at the end of the day's work, or a jumble of meaningless figures. Forms to be used for recording field data should be reduced, if possible, to pocket size for the sake of convenience. Two such forms are suggested in this bulletin, the sheets being 4¾ in. wide by 10½ in. long. It is not expected that these forms will meet all the requirements for every system, but it is believed that they are correct in principle, and with slight modifications will be found applicable for any organization doing highway work.

The forms designed and suggested herein are based upon and developed from the great number of various forms now in use in highway work throughout the United States and Canada. The same form is used for labor and equipment operations, but an additional form is necessary for materials, as it would be awkward to make out individual sheets for each kind of material. The daily summary of costs, and the periodic and total summary cost sheets are included, to show the final disposition and use of the data collected on the daily record forms. The final summaries also will fulfill the purpose of a final record of the cost of any job, and can be published for the purpose of substantiating and justifying the amounts expended.

Additional forms are necessary to record progress and character of the work by the supervising engineer, and the methods and amounts of payments made upon the work. Such forms will be treated in a subsequent bulletin.

The cost-recording forms are outlined and used as follows:

DAILY TIME AND COST RECORD

ROAD B.&W. SECTION 4 8/29/17 DATE

LOCATION On Road ~~C. M.~~ R.

	Labor or Equipment	Time On	Time Off	Hrs.	Rate	Total Amount	Code 11-59 Hrs.	Code 11-59 Amt.	Code 23-06 Hrs.	Code 23-06 Amt.	Code 27-34 Hrs.	Code 27-34 Amt.
	F. Smittie	7.00	5.00			4 40						
Sent to Rosetta	Laborer 1	″	4.30	8½	.375	3 19					~~IIII~~III½	3 19
	2	″	″	″	″	3 19					~~IIII~~III½	3 19
	3	″	″	″	″	3 19					~~IIII~~III½	3 19
	4	″	″	″	″	3 19					~~IIII~~III½	3 19
	5	″	″	″	″	3 19					~~IIII~~III½	3 19
	6	″	″	″	″	3 19					~~IIII~~III½	3 19
	7	″	″	″	″	3 19					~~IIII~~III½	3 19
	8	″	″	″	″	3 19					~~IIII~~III½	3 19
	9	″	″	″	″	3 19					~~IIII~~III½	3 19
	10	″	″	″	″	3 19					~~IIII~~III½	3 19
	11	″	″	″	″	3 19					~~IIII~~III½	3 19
	12	″	4.00	8	″	3 00	II	75	I	37	~~IIII~~	1 88
	13	″	″	″	″	3 00					~~IIII~~III	3 00
	14	″	″	″	″	3 00					~~IIII~~III	3 00
	15	″	″	″	″	3 00	~~IIII~~	1 88	I	37	II	75
	16	″	5.00	9	″	3 37					~~IIII~~IIII	3 37
	17	″	″	″	″	3 37	~~IIII~~IIII	3 37				
				TOTAL				6 00		74		47 09
							23-56		23-61		27-56	
Sent to Rosetta	18	″	9.00	2	.375	75			II	75		
	19	″	″	″	″	75			II	75		
	20	″	″	″	″	75			II	75		
	21	″	″	″	″	75			II	75		
	Engineer 4	″	5.00	8	.50	4 00	III	1 50			~~IIII~~	2 50
	Roller 1	″	″			5 00	III	5 00				
	″ 2	″	″			5 00					~~IIII~~	5 00
	Team 2	10.00	12.00	2		1 50	I	75			I	75
	Guard 1	7.00	5.00	9		2 80						
	″ 2	″	″	9		2 80						
	Waterboy 2	″	″	9		88	Half time to Rosetta					
				TOTAL				7 25		3 00		8 25
		Mixing Plant closed down at 4 P. M.										
				Gang sent to Rosetta								
					TOTAL	83 21						

Fig. 2

DAILY TIME AND COST RECORD

ROAD B.&W. SECTION 4 8/29/17 DATE

LOCATION On Road ~~C. M.~~ R.

	Labor or Equipment	Time On	Time Off	Hrs.	Rate	Total Amount	Code 19-17 Hrs.	Code 19-17 Amt.	Code 22-61 Hrs.	Code 22-61 Amt.	Code 23-61 Hrs.	Code 23-61 Amt.
	F. Rosetta	7.00	5.00			3 75						
	Laborer 22	″	″	9	.375	3 37	~~IIII~~I	2 25	III	1 12		
	23	″	″	″	″	3 37	~~IIII~~I	2 25	III	1 12		
	24	″	″	″	″	3 37	~~IIII~~II	2 62	II	75		
	25	″	″	″	″	3 37	~~IIII~~II	2 62	II	75		
	26	″	″	″	″	3 37	~~IIII~~IIII	3 37				
	27	″	″	″	″	3 37	~~IIII~~IIII	3 37				
	28	″	″	″	″	3 37	~~IIII~~IIII	3 37				
	29	″	″	″	″	3 37	~~IIII~~IIII	3 37				
	30	″	″	″	″	3 37	~~IIII~~IIII	3 37				
	31	″	″	″	″	3 37	~~IIII~~IIII	3 37				
From Smittie's Gang	18	9.00	″	7	″	2 62					~~IIII~~II	2 62
	19	″	″	″	″	2 62					~~IIII~~II	2 62
	20	″	″	″	″	2 62	III	1 12	III	1 12	I	37
	21	″	″	″	″	2 62	III	1 12	III	1 12	I	37
From Carter's Gang	32	10.00	″	6	″	2 25	~~IIII~~I	2 25	TOTAL	5 98		
	33	″	″	″	″	2 25	~~IIII~~I	2 25				
	34	″	″	″	″	2 25	~~IIII~~I	2 25				
	35	2.00	″	3	″	1 12	III	1 12				
From Smittie's Gang	11	4.00	″	1	″	37	I	37				
	12	″	″	″	″	37	I	37				
	13	″	″	″	″	37	I	37				
	14	″	″	″	″	37	I	37				
	15	″	″	″	″	37	I	37				
	1	4.30	″	½	″	18	½	18				
	2	″	″	″	″	18	½	18				
	3	″	″	″	″	18	½	18				
	4	″	″	″	″	18	½	18				
	5	″	″	″	″	18	½	18				
	6	″	″	″	″	18	½	18				
	7	″	″	″	″	18	½	18				
	8	″	″	″	″	18	½	18				
	9	″	″	″	″	18	½	18				
	10	″	″	″	″	18	½	18	22-56			
	Engineer 2			6	.666	4 00	~~IIII~~	3 33	I	67		
	Roller 3			6	.833	5 00	~~IIII~~	4 17	I	83		
									TOTAL	1 50		
	Waterboy 2					87	Half time with Smittie					
					TOTAL	69 32		51 22				5 98

Fig. 3

Form No. 2 (Fig. 2) provides for 40 entries of men or equipment or both and their use on six classifications. The amount for each individual item can be given both in money and in total hours.

This form shows that on Aug. 29, 1917, the foreman F. Smittie employed a gang of laborers numbered from 1 to 21; engineer, No. 4; rollers, No. 1 and No. 2; team, No. 2; guards Nos. 1 and 2; and waterboy, No. 2, on reconstruction work on the B. and W. Road, section 4.

These codes show they were employed as follows:

11–59 Grade and roadside, shoulders, shaping.
23–06 Roadway, base course, cleaning.
23–56 Roadway, base course, rolling.
23–61 Roadway, base course, spreading.
27–34 Roadway, top course, laying.
27–56 Roadway, top course, rolling.

Notes on the sheet show that four laborers were transferred to foreman Rosetta at 9 a. m. and a large part of the crew between 4 and 4:30 p. m.

The daily record of foreman Rosetta's crew (Fig. 3) shows on the same road a crew of 33 laborers, a water boy, roller, and engineer on classifications—

19–17 Grade and roadside, miscellaneous, excavating, common.
22–56 Roadway, sub-base course, rolling.
22–61 Roadway, sub-base course, spreading.
23–61 Roadway, base course, spreading.

Laborers were received three times during the day from foreman Smittie and once from foreman Carter.

In Fig. 4 is shown the work of a large crew, but on only two operations. A number of changes in the crew will be observed. Only 15 men out of a total of 36 employed worked the full day with foreman A8.

DAILY TIME AND COST RECORD

ROAD Route 2 SECTION A 8/24/17 DATE
LOCATION On Road C. ~~M.R.~~

LABOR OR EQUIPMENT	TIME ON	TIME OFF	HRS	RATE	TOTAL AMOUNT	CODE 11-59 HRS.	AMT.	CODE 20-59 HRS.	AMT.	CODE HRS.	AMT.
A8	7.00	6.00	10	.625	6 25						
Laborer 174	"	8.30	1½	.375	55	1½	55	Fired			
187	9.30	2.30	4	"	1 50	||||	1 50	Fired			
188	"	"	4	"	1 50	||||	1 50	Sent to Tool House			
189	"	6.00	7½	"	2 80			卌||½	2 80		
197	"	2.30	4	"	1 50	||||	1 50	Sent to Tool House			
199	"	6.00	7½	"	2 80			卌||½	2 80		
408	7.00	"	10	"	3 75			卌卌	3 75		
414	8.00	"	9	"	3 37	卌||||	3 37				
431	7.00	"	10	"	3 75			卌卌	3 75		
432	"	"	10	"	3 75			卌卌	3 75		
437	11.00	"	6	"	2 25	卌|	2 25				
439	7.00	"	10	"	3 75			卌卌	3 75		
440	"	"	10	"	3 75			卌卌	3 75		
448	"	"	10	"	3 75	卌卌	3 75				
454	"	"	10	"	3 75	卌卌	3 75				
465	"	"	10	"	3 75	卌|	2 25	||||	1 50		
469	"	"	10	"	3 75	卌卌	3 75				
470	"	"	10	"	3 75	卌	1 87	卌	1 88		
475	"	"	10	"	3 75	卌卌	3 75				
477	"	8.30	1½	"	55	1½	55	Sent to Steam Shovel 2			
478	"	6.00	10	"	3 75			卌卌	3 75		
479	"	"	10	"	3 75	卌卌	3 75				
484	"	8.30	1½	"	55	1½	55	Sent to Steam Shovel 2			
485	"	"	1½	"	55	1½	55				
486	"	"	1½	"	55	1½	55				
487	"	9.30	2½	"	93	||½	93	Fired			
495	"	8.30	1½	"	55	1½	55	Sent to Steam Shovel 2			
500	"	4.00	8	"	3 00			卌|||	3 00		
501	"	8.30	1½	"	55	1½	55	Sent to Steam Shovel 2			
506	"	6.00	10	"	3 75	Carrying Water					
532	"	"	10	"	3 75	卌卌	3 75				
568	11.00	"	6	"	2 25	卌|	2 25				
599	"	12.00	1	"	37	1	37	Sent to Tool House			
195	"	2.30	1½	"	55			1½	55	Sent to Tool House	
Team 21	7.00	12.00	5	.80	4 00			卌	4 00		
" 22	"	"	5	"	4 00			卌	4 00		
Grader	"	"	5	.50	2 50			卌	2 50		
TOTAL					99 67		44 14		45 53		

Fig. 4

DAILY RECORD OF MATERIALS AND SUPPLIES

ROAD Ashland-Lexington SECTION Cemetery Bridge DATE Sept. 19, 1910 FOREMAN B. Messing C. ~~M.R.~~

KIND	UNIT	RATE	43-39 UNITS	AMOUNT	41-39 UNITS	AMOUNT	43-25 UNITS	AMOUNT	43-47 UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT
Cement	Bag	.47	150	70 50	10	4 70								
Lumber	M	30.00					1.2	36 00						
Nails	lb.	.035					20	70						
Wire	lb.	.035					10	35	8	28				
Gasoline	Gal.	.20	5	1 00	1	20								
Sand	C.Y.	.60	22	13 20	2	1 20								
Steel	lb.	.03							7800	234 00				
Oil				10										
TOTAL AMOUNTS				84 80		6 10		37 05		234 28				
WHERE USED			West Span		East Abutment		West Span		3 West Spans					

Fig. 5

Material and Supplies.—The form for materials and supplies (Fig. 5) is the same size as that for labor and equipment and may be carried by the timekeeper or foreman in the same book or binder with the other form. The material form is for one day only and 12 different materials may be recorded on a single sheet. The sheet shows distribution as follows:

For Operation 43-39, Mixing and Placing Superstructure

150 bags cement, at $0.47	$ 70.50
5 gal. gasoline, at $0.20	1.00
22 cu. yd. sand, at $0.60	13.20
Oil	.10
Total for operation (used on west span)	84.80

For Operation 41-39, Mixing and Placing Abutment

10 bags cement, at $0.47	$ 4.70
1 gal. gasoline, at $0.20	.20
2 cu. yd. sand, at $0.60	1.20
Total for operation (used on east abutment)	6.10

For Operation 43-25, Forming Superstructure

1,200 ft. b. m. lumber, at $0.03	$ 36.00
20 lb. nails, at $0.035	.70
10 lb. wire, at $0.035	.35
Total for operation (used on west span)	37.05

For Operation 43-47, Superstructure, Placing steel

8 lb. wire, at $0.035	$ 0.28
7,800 lb. steel, at $0.03	234.00
Total for operation (used on 3 west spans)	234.28

DAILY TIME AND COST RECORD

ROAD *Route 2* SECTION *A* *8/25/17* DATE

LOCATION *40+75 to 45+00* C. ~~M.R.~~

LABOR OR EQUIPMENT	TIME ON	TIME OFF	HRS	RATE	TOTAL AMOUNT	CODE 23-34 HRS	CODE 23-34 AMT.	CODE 20-59 HRS.	CODE 20-59 AMT.	CODE 23-12 HRS.	CODE 23-12 AMT.
F. Waugh	7.00	6.00	10	.75	7 50						
Laborer 592	"	"	"	.412	4 12	𝍸𝍸	4 12				
601	"	"	"	"	4 12	𝍸/	2 47			////	1 65
610	"	"	"	"	4 12	𝍸	2 06			𝍸	2 06
590	"	"	"	"	4 12	𝍸	2 06			𝍸	2 06
589	"	"	"	"	4 12	///	1 24	///	1 24	////	1 64
533	"	"	"	"	4 12	𝍸	2 06			𝍸	2 06
546	9.00	"	8	"	3 30	𝍸	2 06	///	1 24		
481	10.00	"	7	"	2 88	𝍸/	2 47	/	41		
474	7.00	"	10	"	4 12	𝍸𝍸	4 12				
473	"	"	"	"	4 12	𝍸///	3 30			//	82
467	"	"	"	"	4 12	𝍸///	3 30			//	82
466	"	"	"	"	4 12	𝍸///	3 30	//	82		
422	10.00	"	7	"	2 88	𝍸//	2 88				
					TOTAL	86	35 44				
						11-59					
420	7.00	6.00	10	.412	4 12	𝍸/	2 47	///	1 24	/	41
425	"	"	"	"	4 12	𝍸///	3 30	//	82		
					TOTAL	14	.5 77	14	5 77	28	11 52
						23-56		23-31			
Team 9	7.00	6.00	10	.80	8 00			𝍸𝍸	8 00		
12	"	"	"	"	8 00			𝍸𝍸	8 00		
15	"	"	"	"	8 00			𝍸𝍸	8 00		
16	"	"	"	"	8 00			𝍸𝍸	8 00		
17	"	"	"	"	8 00			𝍸𝍸	8 00		
18	"	"	"	"	8 00			𝍸𝍸	8 00		
23	"	"	"	"	8 00			𝍸𝍸	8 00		
Waterboy 115	"	"	"	.275	2 75						
Engineer 169	"	"	"	.625	6 25	𝍸𝍸	6 25				
Roller 13		Day			8 00	Day	8 00				
Team 5	8.00	6.00	9	.80	7 20			𝍸////	7 20		
19	"	"	"	"	7 20			𝍸////	7 20		
21	"	"	"	"	7 20			𝍸////	7 20		
25	"	"	"	"	7 20			𝍸////	7 20		
30	"	"	"	"	7 20			𝍸////	7 20		
3	2.00	3.00	1	"	80	/	80				
					TOTAL	11	15 05	115	92 00		
TOTAL					175 80						

Fig. 6

DAILY RECORD OF MATERIALS AND SUPPLIES

ROAD *Route 2* SECTION *A* DATE *8/25/17* *F. Waugh* FOREMAN C. ~~M.R.~~

CODES, UNITS, AND AMOUNTS

KIND	UNIT	RATE	23-34 UNITS	23-34 AMOUNT	23-56 UNITS	23-56 AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT	UNITS	AMOUNT
Fld. Stone	C.Y.	.25	87	21 75												
Coal	Ton	4.00			.25	1 00										
TOTAL AMOUNTS				21 75		1 00										
WHERE USED			43+75 to 41+50		45+00 to 41+00											

Fig. 7

Daily Report of Costs.—When the records of the amount of labor, the service of equipment, and the expenditures of materials have been completed the data for arriving at unit costs are at hand. For convenience in bringing together these three elements of cost, a form has been drawn up called the "Daily report of costs." This is not for field use and is 8½ in. wide and 13½ in. long. The unit costs are arrived at by setting down against the code number all labor equipment and material charges in detail. These are added together and the sum is divided by the units of work completed as estimated by the foreman. The units completed are checked against the engineer's monthly estimate and should not show a very great discrepancy, say not over 5 per cent at the outside.

Sample labor and equipment and materials forms for work of constructing a field stone base course of a road and the daily report of costs form filled out from these are shown in Figs. 6, 7 and 9.

These three forms compose the entire set needed to record the field operations and compute unit costs of such operations.

Immediate Use of Cost Data.—When the daily reports of costs reach the official responsible for the work he can readily prepare a graph (Fig. 8) showing both the estimated unit cost and the actual daily unit cost in convenient form. Any wide divergence between the estimated and actual costs is apparent at once and can be investigated. The horizontal axis of the graph in this case is divided to show the days of the month. The vertical axis is divided to show the unit cost of the work. Some such chart will show effect of conditions upon the work.

Final Disposition of Cost Data.—It has been pointed out that the objects of a cost-keeping system are two. First, to show the efficiency of performance and facilitate the reduction of costs, and, second, to supply data which may be used for the intelligent estimating of future improvements and to furnish materials for published reports.

Highway work obviously is a public improvement paid for entirely from funds derived from the public revenue. Ultimately, then, the taxpayer pays for all of this improvement and is entitled to a full and detailed account of how this money was expended. Again, public records of this kind are all that remain to be used for the comparing of the efficiency of one administration with that of another. It would appear, therefore, to be a step in the direction of good judgment for all those in charge of public improvements to adopt some simple system of cost keeping such as is outlined herein, which could be used both as an aid to present efficiency and as a complete report of the ability of the officials in charge to get the most for the public funds.

For the purpose of presenting in concise form the costs and also to show the progress being made during the period of construction the form, "Report of Progress and Cost," is suggested. The costs which comprise this report may be compiled from daily reports. Such compilation may be made from day to day on a form similar to the one shown. Where the cost data are derived in greater detail than is provided for by this form, the "Cost Compilation Form" may be arranged in several sheets.

The "Final Cost Summary" is for the purpose of bringing together all expenditures involved and all units of work done, and to show unit costs, total cost of parts, per cent of cost by parts, and total cost of the entire improvement.

The daily time and cost record of foreman Waugh's crew (Fig. 6) shows:

86 hours labor on code 23–34 (laying base course) $35.44
14 hours labor on code 11–59 (shaping shoulders) 5.77
14 hours labor on code 20–59 (shaping sub-grade) 5.77
28 hours labor on code 23–12 (crushing base course) 11.52
10 hours labor, 1 hour team hire on code 23–56 (rolling base course) 15.05
115 hours team hire on code 23–31 (hauling base course) 92.00

The daily record of materials and supplies (Fig. 7) shows:

Expenditures for 87 cu. yd. fired stone on code 23–34 (laying base course) $21.75
One-quarter ton coal on code 23–56 (rolling base course) 1.00

These data are combined and arranged on the daily report of costs form (Fig. 9) so as to make possible the ready determination of unit costs. In this case no indirect labor cost is charged to equipment. Teams were used only for hauling and were required to make a certain number of trips per day.

The amount of work done was reported to the superintendent by the engineer in charge of this division of the work.

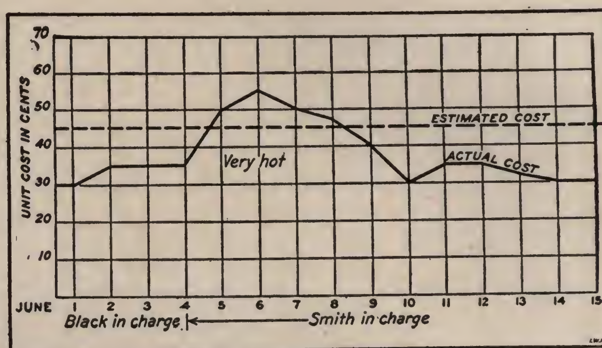


Fig. 8

DAILY REPORT OF COSTS C.~~M.R.~~

ROAD *Route 2* SECTION *A* WEATHER *Clear-Warm* FOREMAN *F. Waugh* DATE *8-25-17*

CODE NUMBERS	LABOR KIND	LABOR HOURS	LABOR RATE	LABOR AMOUNT	EQUIPMENT KIND	EQUIPMENT HOURS	EQUIPMENT RATE	EQUIPMENT AMOUNT	MATERIALS & SUPPLIES KIND	MATERIALS & SUPPLIES UNIT	MATERIALS & SUPPLIES NUMBER	MATERIALS & SUPPLIES RATE	MATERIALS & SUPPLIES AMOUNT	LABOR EQUIPMENT SUPPLIES MATERIALS	UNITS OF WORK COMPLETED NUMBER	UNITS OF WORK COMPLETED UNIT	UNIT COST	LOCATION
11-59	Labor	14	412	5.77														
	Indirect			.94										6.71	300	Per foot	022	43+75 to 40+70
																of road	013	sq. yd. of roadway
20-59	Labor	14	412	5.77														43+75 to 40+75
	Indirect			.94										6.71	533.3	sq. yds.	013	16 ft. wide
23-12	Labor	28	412	11.52														43+75 to 41+48
	Indirect			1.89										13.41	404	sq. yds.	033	16 ft. wide
23-34	Labor	86	412	35.44					Fld. Stone	C.Y.	87	25	21.75					43+75 to 41+48
	Indirect			5.80										62.99	404	sq. yds.	156	16 ft. wide
23-31					Teams	115	80	92.00						92.00	404	sq. yds.	228	43+75 to 41+48
23-56	Engineer	10	625	6.25	Team	1	80	.80	Coal	Ton	.25	4.00	1.00					45+00 to 41+00
	Indirect			.67	Roller	day		8.00						16.72	711	sq. yds.	024	16 ft. wide
Totals		152		74.99				100.80					22.75	198.54	Per sq. yd. siding		467	
Indirect	Foreman	10	75	7.50	Basis for distribution													
	Wt. Boy	10	275	2.75	Indirect labor expenses													
	Labor	152	0674	10.25	on direct labor costs.													

Fig. 9

REPORT OF PROGRESS AND COST.

Road No. 144—Sections A. Construction. Period from Mar. 1 to 15, 1917.

Code Nos.	Classification.	Unit.	For this period.			Summary to date.			Completed.
			Units completed.	Total cost.	Unit cost.	Units completed.	Total cost.	Unit cost.	
	Right of way:								Per cent.
01–26	Plans and surveys, general						$400.00		100
02	Real estate	Acre	10	$500.00	$50.00	25	1,500.00	60.00	80
09	Miscellaneous			600.00			1,200.00		85
	Grade and roadside:								
19–08	Clearing and grubbing	Acre	4	160.00	40.00	19	950.00	50.00	57
19–17	Miscellaneous, excavation, common	Cubic yard	500	150.00	.30	2,000	500.00	.25	50
	Roadway:								
20–59	Subgrade, shaping	Square yard	1,200	36.00	.03	16,000	64.00	.04	10
23–34	Base course, laying	do	1,000	900.00	.90	16,000	14,400.00	.90	10
27–34	Top course, laying	do	1,600	960.00	.60	1,600	960.00	.40	1
	Ditches and drains:								
31–17	Paved gutter, excavation, common	Linear foot	400	8.00	.02	1,000	30.00	.03	6
31–34	Paved gutter, laying	do	200	80.00	40	800	320.00	.40	5
33–34	Tile drains, laying	do	50	15.00	.30	50	15.00	.30	2
33–26	Catch basins, general		2	40.00	20.00	3	60.00	22.00	25
	Bridges and culverts:								
40–17	Foundations, excavation, common	Cubic yard	2,000	1,600.00	.80	3,000	2,400.00	.80	80
40–45	Foundations, piling, driving	Linear foot	1,200	480.00	.40	2,000	1,000.00	.50	45
40–26	Foundations, general	Cubic yards	125	1,457.50	11.50	125	1,457.50	11.50	80
41–26	Abutments, general	do	400	3,600.00	9.00	400	3,600.00	9.00	60
43–26	Superstructures, general	do	120	1,920.00	16.00	120	1,920.00	16.00	
49–26	Bridges and corrugated pipe culverts, general	Linear foot	150	300.00	2.00	150	300.00	2.00	40
	Supplementary parts:								
50–26	Signs and sign posts, general		75	150.00	2.00	100	210.00	2.10	50
52–26	Guardrails, general	Linear foot	100	100.00	1.00	300	300.00	1.00	40
53–26	Curbs, general	do	1,000	200.00	.20	2,000	450.00	.22½	20
59–26	Monuments, general		10	30.00	3.00	10	30.00	3.00	40
	Engineering and supervision:								
67–26	Supervisory engineering, general			60.00			300.00		
68–26	Inspection, general			100.00			500.00		
69–	Miscellaneous			10.00			15.00		
	Total expenditures			13,456.00			32,887.50		

COST COMPILATION.

Road No. ....
Sections............
Work begun.........
Completed..........

......................Superintendent.

Construction.
Maintenance.
Reconstruction.

Date.		Source of Item.	Right of way.			Grade and Roadside.		Roadway.			Ditches and drains.				Bridges and culverts.						Supplementary parts.				Engineering and supervision.			Administration.		Totals.
Mo.	Day.		01–26	02–	09–	19–08	19–17	20–59	23–34	27–34	31–17	31–34	33–34	33–26	40–17	40–45	40–26	41–26	43–26	49–	50–26	52–26	53–26	59–26	67–26	68–26	69–	97–	99–	

FINAL COST SUMMARY.

Road ....
Sections ....
....
Sup't.

Cost of Construction ....
Date of Acceptance..............

[Items including cost of labor, materials, supplies, and rental of equipment.]

Road part.	Operation.	Code.	Units.	Unit cost.	Cost.	Total cost.	Percentage of whole cost.
Right of way:							
Plans and surveys	General	01–26	Acres				Per cent.
Real estate		02–	do				
Miscellaneous		09–	do				
Grade and roadside:							
Miscellaneous	Clearing and grubbing	19–08	do				
Miscellaneous	Excavation, common	19–17	Cu. yd				
Roadway:							
Subgrade	Shaping	20–59	Sq. yd				
Base course	Laying	23–34	do				
Top course	Laying	27–34	do				
Ditches and drains:							
Paved gutter	Excavation, common	31–17	Lin. ft				
Paved gutter	Laying	31–34	do				
Tile drains	Laying	33–34	do				
Catch basins	General	33–26	Only				
Bridges and culverts:							
Foundations	Excavation, common	40–17	Cu. yd				
Foundations	Piling, driving	40–45	Lin. ft				
Foundations	General	40–26	Cu. yd				
Abutments	General	41–26	do				
Superstructures	General	43–26					
Miscellaneous		49–					
Supplementary parts:							
Signs and sign posts	General	50–26	Lin. ft				
Guard rails	General	52–26	do				
Curbs	General	53–26	do				
Miscellaneous		59					
Engineering and supervision:							
Supervisory engineering	General	67–26					
Inspection	General	68–26					
Miscellaneous		69					
Administration:							
Engineering, departmental		97					
Miscellaneous		99					
Grand total							

State Highway Construction Costs in 1927

Average Unit Bidding Prices in 1927 on State Highway Work

Maine—

Items	Unit	Average Unit Bid
Earth Excavation	Cu. Yd	$ 1.126
Rock Excavation	Cu. Yd.	3.80
Borrow	Cu. Yd.	1.106
Stone Fill	Cu. Yd.	2.375
Gravel Base	Cu. Yd.	1.865
Stone Base	Cu. Yd.	2.822
Gravel Sub-base	Cu. Yd.	2.156
Catch Basins	Each	100.00
Side Underdrain	Lin. Ft.	1.50
Class "A" Concrete	Cu. Yd.	26.333
Class "B" Concrete	Cu. Yd.	23.833
Cement Rubble-Masonry	Cu. Yd.	10.00
Rip-rap	Lin. Ft.	2.50
Drop Inlets	Each	65.00
Cobble Gutters	Sq. Yd.	1.50
Gravel Road	Cu. Yd.	1.959
Crushed Stone base course	Cu. Yd.	4.375
Bit. Macadam surface course	Cu. Yd.	5.125
Bit. Material app. (bbls.)†	Gal.	.055
Portland Cement Conc. pavement	Cu. Yd.	12.25
Pavement Reinforcing Bars	Lb.	.0433
Wire Cable Guard Rail	Lin. Ft.	.825
Laying 12 in. C. M. P. Culverts	Lin. Ft.	.764
Laying 15 in. C. M. P. Culvert	Lin. Ft.	.761

†Material furnished by state. Price bid is for delivery from railroad station, heating and applying.

North Carolina—

	Average Width Surf. Ft.	Thickness, In.	Average Cost Per Mile
Plain Concrete†	16 & 18	8-6-8	$25,000
Bituminous Macadam	16 & 18	8†	7,700
Bituminous Concrete	16 & 18	7††	27,000
Macadam	16	8	14,000
Gravel, Top Soil, Stone, Sand, Clay	30-35	9	9,000
Sand-Asphalt	18	5††	17,000
Graded and Drained	30-35	......	8,500
Road Oil Treatment	....	......	5,200

†8-6-8 also in 6 in. uniform. †8 in., 2 layers. ††5 in. base, 2 in. top. ††3 in. base, 2 in. top.

Pennsylvania—

Average Unit Prices of Work Recommended for Award by Pennsylvania Department of Highways, from Jan. 1 to Nov. 1, 1927

Reinforced Concrete Surface Roads

(Type Pavement Only)

	Width Ft.	Sq. Yd.	—Unit Prices— Per Sq. Yd.	Per Cu. Yd.
7-5½-7	16	89,034	$2.71	$16.88
7½-5½-7½	16	100,703	2.63	15.32
7½-6-7½	16	384,481	2.81	16.08
7½-5½-7½	18			
7½-6-7½	18	87,188	2.65	15.19
8-6-8	16	441,768	2.88	15.53
8-6-8	18	403,328	2.70	14.57
8½-6-8½	18			
8½-6½-8½	18	27,108	3.10	15.57
9-7-9	18	1,164,322	3.01	14.11
9-7-9	20	143,633	2.98	13.98
10-7-10	20	35,656	3.17	14.27
10-8-10	20	14,133	3.60	14.96
6-in. Uniform	Variable			
6½-in. Uniform	"	49,489	2.82	15.63
7-in. Uniform	"	174,946	2.87	14.78
7½-5½-7½	"			
8-6-8	"	24,289	2.94	....
9-7-9	"	48,338	2.87	....

Additional Types of Surfaced Roads, All Surface Items

	Width	Sq. Yd.	Per Sq. Yd.
7½-6-7½	16	60,995	$1.44
B. S. T. M.			
Bit. Sur. Cr. Sp. "A"	Variable	19,304	1.60
Bit. Sur. Cr. Sp. "E"	"	3,946	1.68
3-in. Vit. Brick	"	37,207	2.32
8-6-8 B. S. T. M.	16	30,757	1.85
3-in. Pene. Reconst. Base Course	16	30,462	1.10

Idaho—

Items	Unit	Average Unit Bid
Solid Rock Excavation	Cu. Yd.	$ 1.11
Loose Rock Excavation	Cu. Yd.	.51
Earth Excavation	Cu. Yd.	.32
Unclassified Excavation	Cu. Yd.	.463
Concrete Class "A"	Cu. Yd.	27.55
Metal Reinforcing	Lb.	.074
Crushed Gravel or Rock Surfacing	Cu. Yd.	1.748
Surfacing Binders	Cu. Yd.	.53
Rip Rap, Loose	Cu. Yd.	1.31
Rip Rap, Hand Placed	Cu. Yd.	4.13
Guard Rail	Cu. Yd.	.896
Haul on Surface and Binder	Mi. Yd.	.222
Unload, Haul and Place 12 G. I. P.	Ft.	.36
18 G. I. P.	Ft.	.47
24 G. I. P.	Ft.	.62
30 G. I. P.	Ft.	.77
36 G. I. P.	Ft.	.67

New Mexico—

Items	Unit	Average Unit Bid
Common Excavation	C. Yd.	$ 0.22
Rock Excavation	Cu. Yd.	1.50
Borrow	Cu. Yd.	.22
Overhaul	Sta. Yd.	.03
Gravel Surfacing	Cu. Yd.	1.59
Cruched Rock Surfacing	Cu. Yd.	2.76
Mortar Rubble Masonry	Cu. Yd.	15.00
Rip Rap	Cu. Yd.	6.00
24-in Diameter Corr. Metal Culvert	Lin. Ft.	2.83
30-in. Diameter Corr. Metal Culvert	Lin. Ft.	3.53
36-in. Diameter Corr. Metal Culvert	Lin. Ft.	5.00
Class "A" Concrete	Cu. Yd.	22.00
Class "B" Concrete	Cu. Yd.	23.00
Cement Concrete Pavement	Cu. Yd.	16.75
Asphalt Expansion Joint	Lin. Ft.	.15
Reinforcing Steel	Lb.	.08
Woven Wire Guard Fence	Lin. Ft.	.97
Plating	Cu. Yd.	.55
Spillway Base Course	Cu. Yd.	3.55
Clearing and Grubbing	Acre	14.00
Moving Fence	Lin. Ft.	.02
Federal Markers	Each	12.75
Ditch and Dike	Lin. Ft.	.05
Creosoted Timber (Box Culverts)	M. B. M.	155.00
Creosoted Timber (Superstructure)	M. B. M.	165.00
Creosoted Timber (Substructure)	M. B. M.	165.00
Creosoted Timber Piles	Lin. Ft.	1.70
Bridge Excavation	Cu. Yd.	2.00
Asphalt Wearing Surface	Sq. Yd.	.90

North Dakota—

Items	Unit	Average Unit Bid
Earth Excavation	Cu. Yd.	$ 0.32
Overhaul	Cu. Yd. Sta.	.015
Wire Rope Guard Rail	Cu. Ft.	.60
Wood Guard Posts	Each	1.00
Class "A" Concrete	Yd.	25.00
Reinforcing Steel	Lb.	.065
Preparing Subgrade for Gravel Surfacing	Mile	75.00
Load, unload, compact and maintaining	Cu. Yd.	.23
Gravel Hauling	Cu. Yd. Mile	.17
Screening	Cu. Yd.	.03

West Virginia—

Items	Unit	Average Unit Bid
Unclassified Excavation	Cu. Yd.	$ 0.70
Concrete Pavement	Cu. Yd.	14.50
Class "A" Concrete	Cu. Yd.	20.00
Class "B" Concrete	Cu. Yd.	18.00
Stone Base	Cu. Yd.	5.00
Top for Bituminous Macadam Roads	Sq. Yd.	.75
Oil Asphalt Applied	Gal.	.18
Tar Applied	Gal.	.20
Wire Cable Guard Rail	Ft.	.60

Nevada—

Items		Average Price Bid
Excavation Unclassified	Cu. Yd.	$ 0.49
Overhaul	Yd. Sta.	0.02
Prepare Subgrade and Shoulders	Miles	107.22
Excavation—Type 1	Cu. Yd.	0.80
Excavation—Type 2	Cu. Yd.	0.26
Crushed Gravel Surface in Place	Cu. Yd.	1.36
Class "A" Concrete	Cu. Yd.	35.43
Class "B" Concrete	Cu. Yd.	36.72
15 in. C.M.P. f.o.b. nearest siding	Lin. Ft.	0.96
18 in. C.M.P. f.o.b. nearest siding	Lin. Ft.	1.11
24 in. C.M.P. f.o.b. nearest siding	Lin. Ft.	1.66
30 in. C.M.P. f.o.b. nearest siding	Lin. Ft.	2.11
36 in. C.M.P. f.o.b. nearest siding	Lin. Ft.	2.53
18 in. Vitrified Pipe in place	Lin. Ft.	3.00
24 in. Vitrified Pipe in place	Lin. Ft.	5.00
Cement Rubble Masonry	Cu. Yd.	16.00
Monuments	Each	3.72
Timber complete in place	M. Ft. B. M.	150.00
Treated Timber Piles	Lin. Ft.	2.00
Furnishing Watering Equipment	Lump Sum	650.00
Applying Water	M. Gal.	1.83
Rip Rap	Cu. Yd.	4.70
Prepare grade for Selected Material for Subbase and Shoulders	Miles	50.00
Prepare Subgrade and Shoulders—9 ft. pavement	Miles	1,650.00
Prepare Subgrade and Shoulders—18 ft. pavement	Miles	2,835.00
Cement Concrete Pavement	Sq. Yd.	0.96
Erecting Woven Wire Guard Fence	Lin. Ft.	0.82
Selected Material for Subbase and Shoulders complete in place	Cu. Yd.	0.65
Remove and Reset Fence	Lin. Ft.	0.06
Structure Excavation	Cu. Yd.	2.50
Structural Steel in place	Lbs.	0.075
Steel Reinforcement in place	Lbs.	0.06
Installing 15 in. C.M.P.	Lin. Ft.	0.75
Installing 18 in. C.M.P.	Lin. Ft.	0.79
Installing 24 in. C.M.P.	Lin. Ft.	0.79
Installing 30 in. C.M.P.	Lin. Ft.	1.43
Installing 36 in. C.M.P.	Lin. Ft.	1.25
Hand Placed Rock Fill	Cu. Yd.	5.25
Clearing Right of Way	Acres	100.00
Widening President Roadway	Lin. Mi.	240.00
Widening Present Surface	Lin. Mi.	70.00
Pipe Culvert Extensions	Each	10.00
18 in. C.M.P. in place	Lin. Ft.	1.89
24 in. C.M.P. in place	Lin. Ft.	2.50
30 in. C.M.P. in place	Lin. Ft.	3.26
36 in. C.M.P. in place	Lin. Ft.	4.00

Average Cost State Highway Completed in 1927

Maine—

Type	Miles	Av. Width Surface Ft.	Thickness In.	Av. Cost Per Mile
Reinforced Concrete	7.17	27	7-9	$71,300
Reinforced Concrete	3.89	20	7-9	52,800
Reinforced Concrete	3.98	18	7-9	46,900
Bituminous Macadam*	7	20	....	32,600
Gravel**	40	18	....	19,400

*2½ in. Surface; 10 in. to 12 in. base.

**4 in. to 6 in. surface; 8 in. to 10 in. base.

Rhode Island—

Reinforced Concrete	15.90	20	8	$53,600
Bituminous Macadam	20.66	20	8	33,700
Sheet Asphalt	2.10	30	3″ Sheet on 6″ Con. Base	47,000
Macadam	2.00	18	8	22,700

Indiana—

Plain Concrete	266	18	9-7-9	$27,000
Bituminous Macadam	72	18	7-9	18,000
Resurfacing Bituminous Conc.	0.56	18	....	14,000
Macadam	75	....	....	7,000
Gravel	55	....	....	5,000
Bituminous Retread Top	117	20	2	5,000

Missouri—

Plain Concrete	77	9	6	$15,000
Plain Concrete	147	18	6	33,000
Comb. 9 ft. Conc. and 7 ft. Gravel	16	16	*	26,000
Gravel	399	18	2	10,000
Graded and Drained	356	30	....	14,000

*9 ft. concrete 6 in. thick; 7 ft. gravel 2 in. thick.

West Virginia—

Plain Concrete	66.65	16	7	$43,000
Bituminous macadam	97.09	16	11	37,000
Gravel	320.79	16	8	20,000
Graded and drained	373.54	26	....	15,000
Stone base	43.75	16	8	27,000

Mississippi—

Brick	5	18	....	$43,000
Plain concrete	59	18	9-6-9	25,000
Gravel	90	16, 18	6*	15,000
Graded and drained	66	24, 26 c	....	5,000

*Compacted.

Idaho—

Plain concrete	1.14	18	9-6-9	$26,281
Bitum. concrete	12.99	18	6	24,257
Macadam	233.7	18	5	11,057
Graded and drained	69.9	24	....	3,243
Oil treated macadam	72	18	2	2,017

Nevada—

Plain Concrete	3.92	18	7-5-7	$30,330
Gravel and Crushed Rock	98.49	15	6½	7,364
Gravel Surface only	15.50	18	6½	3,991
Oiled Gravel, Turnover method	4.76	18	3 Pen.	2,105

Oregon—

Brick				
Plain Concrete	0.9	18	7	$35,000
Reinforced Concrete				
Bituminous Macadam				
Bituminous Concrete	0.2	18	6	30,000
Sheet Asphalt				
Macadam				
Gravel or Broken Stone Surf.	138.3	18	8	7,000
Sand—Asphalt				
Graded and Drained	79.4	24 Rdbed.	....	15,000
Oiling Surfacing	383.5	18	....	900

Ohio—

State Highway Contracts Under Construction Jan. 1 to Oct. 20, 1927

Type	Miles	Contract Price
Concrete	316.779	$ 6,138,282
Surface Treating	247.568	192,523
Traffic Bound Macadam	175.850	352,203
Bituminous Macadam	157.387	4,015,683
Water Bound Macadam	102.527	2,115,994
Brick	82.612	3,921,961
Kentucky Rock Asphalt	23.122	539,954
Sheet Asphalt	4.613	220,584
Warrenite Bitulithic (Hot Mix)	2.520	148,532
Misc. (Guard Rail, Reconstruction widening, etc.)	34.236	684,146
Grading and Drainage Structures	128.020	1,914,282
Bridges (105 Contracts)		2,984,630
Total	1275.234	$23,228,781

Completed Between Jan. 1 to Oct. 20, 1927

Concrete	147.932	$ 2,717,921
Surface Treating	117.220	83,546
Traffic Bound Macadam	117.900	231,868
Bituminous Macadam	70.059	1,750,359
Water Bound Macadam	61.138	1,315,997
Brick	19.233	794,663
Kentucky Rock Asphalt	5.909	133,330
Sheet Asphalt	.218	25,660
Warrenite Bitulithic	2.520	148,532
	7.291	104,107
Grading and Drainage Structures	43.748	489,767
Bridges (50 Contracts)		973,216
Total	593.168	$ 8,768,970

Under Construction Oct. 20, 1927

Concrete	168.847	$ 3,420,360
Surface Treating	130.348	108,976
Traffic Bound Macadam	57.950	120,335
Bituminous Macadam	87.328	2,265,324
Water Bound Macadam	41.389	799,997
Brick	63.379	3,127,298
Kentucky Rock Asphalt	17.213	406,623
Sheet Asphalt	4.395	194,924
Warrenite Bitulithic	26.945	580,039
Grading and Drainage Structures	84.272	1,424,514
Bridges (55 Contracts)		2,011,414
Total	682.066	$14,459,810

Hourly Pay on Federal Aid Projects in 1927

BUREAU OF PUBLIC ROADS
United States Department of Agriculture

Kind of Labor / Geographical Divisions	Common Labor	Foremen	Truck Drivers	Mixer Operators	Steam Shovel Operators	Structural Steel Workers	Carpenters	Concrete Labor	Total Number Men Employed	Convicts Employed
JANUARY										
New England	$0.44	$0.76	$0.46	$0.50	$1.39		$1.06		316	......
Middle Atlantic	.46	.79	.50	....	1.09		.78	$0.50	938	124
East North Central	.39	.72	.44	.66	.88		.64	.49	630	......
West North Central	.38	.75	.42	.51	.88	$0.92	.56	.46	1,566	......
South Atlantic	.24	.48	.30	....	....	.87	.52	....	596	41
East South Central	.24	.62	.33	.36	.91	62	.48	.28	3,295	130
West South Central	.27	.60	.30	.30	.75	....	.49	....	302	......
Mountain	.43	.76	.50	.67	.93	.66	.73	.44	2,481	......
Pacific	.51	1.05	.64	.59	.116	1.25	.90	.64	1,262	77
United States	.38	.75	.46	.54	.99	.75	.65	.46	11,386	372
FEBRUARY										
New England	$0.50	$1.08	$0.70		$1.38				46	......
Middle Atlantic	.50	.77	.49		1.12				146	......
East North Central	.44	.81	.48		....	$0.95	$0.78	$0.75	237	......
West North Central	.37	.75	.42	$0.58	.90	.82	.58	.43	1,074	......
South Atlantic	.29	.57	.30	.39	.88	....	.54	.32	515	15
East South Central	.24	.57	.32	.37	.85	....	.49	.27	2,216	......
West South Central	.32	.74	.50	.30	....	....	.67	.30	63	......
Mountain	.41	.78	.48	.51	1.00	.71	.80	.43	1,844	41
Pacific	.53	.99	.66	.81	1.18	1.32	.88	.60	755	......
United States	.38	.75	.46	.52	1.04	.90	.65	.42	6,896	56
MARCH										
New England	$0.51	$0.86	$0.58	$0.89	$1.22				198	......
Middle Atlantic	.51	.83	.50	.70	1.14	$0.70	$0.70	$0.60	306	......
East North Central	.39	.67	.38	....	.71	....	.70	....	236	......
West North Central	.37	.74	.41	.42	.96	.67	.57	.40	1,520	......
South Atlantic	.32	.54	.29	.57	.75	.54	.54	.27	584	74
East South Central	.24	.57	.31	.36	.78	....	.50	.26	1,730	38
West South Central	.26	.64	.31	....	.80	....	.60	.35	239	......
Mountain	.42	.75	.48	.50	.98	.58	.73	.43	1,601	......
Pacific	.52	.98	.68	.91	1.16	1.25	.86	.62	889	35
United States	.38	.74	.46	.56	.98	.65	.62	.43	7,303	147
APRIL										
New England	$0.49	$0.81	$0.55	$0.78	$1.16		$0.86	$0.53	1,930	......
Middle Atlantic	.47	.82	.51	.78	1.08	$0.70	.80	.54	4,057	30
East North Central	.38	.67	.42	.68	.82	....	.69	.48	1,875	......
West North Central	.38	.75	.41	.61	.91	1.00	.59	.44	4,907	......
South Atlantic	.25	.54	.29	.58	.74	.50	.49	.33	1,239	212
East South Central	.25	.60	.34	.43	.88	.80	.48	.28	4,607	30
West South Central	.34	.67	.36	.44	.77	....	.48	.42	283	......
Mountain	.43	.78	.52	.54	.99	.88	.78	.41	3,261	......
Pacific	.52	.97	.65	.86	1.13	1.25	.89	.60	1,455	109
United States	.39	.75	.47	.66	1.00	.95	.68	.45	23,614	381
MAY										
New England	$0.49	$0.80	$0.58	$0.90	$1.22		$0.99	$0.56	2,162	......
Middle Atlantic	.46	.80	.50	.75	1.08	$0.72	.82	.51	2,654	......
East North Central	.37	.66	.41	.60	.76	....	.62	.43	2,151	......
West North Central	.38	.74	.42	.77	.95	.50	.61	.47	4,422	......
South Atlantic	.27	.56	.32	.56	.75	....	.51	.31	775	226
East South Central	.24	.66	.32	.44	.89	.60	.51	.28	2,627	30
West South Central	.26	.60	....	....	....	....	....	....	75	......
Mountain	.45	.74	.50	.52	.98	.82	78	.46	2,294	......
Pacific	.50	.94	.68	.86	1.11	1.06	.91	.63	973	97
United States	.40	.74	.47	.68	1.01	.84	.69	.45	18,133	353
JUNE										
New England	$0.51	$0.79	$0.55	$0.87	$1.17	$1.50	$0.93	$0.60	3,199	......
Middle Atlantic	.46	.83	.51	.77	1.09	.80	.82	.52	6,806	40
East North Central	.38	.68	.43	.69	.80	....	.73	.47	5,650	......
West North Central	.38	.73	.41	.72	.87	.70	.59	.46	8,290	......
South Atlantic	.29	.61	.34	.48	.78	....	.49	.35	993	160
East South Central	.25	.65	.32	.45	.94	.40	.51	.29	3,895	......
West South Central	.26	.60	....	.30	.88	....	.70	.28	170	......
Mountain	.44	.75	.54	.60	1.08	.85	.80	.48	2,488	......
Pacific	.54	.94	.66	1.00	1.16	1.25	.95	.64	1,624	177
United States	.40	.74	.47	.73	1.01	.91	.71	.48	33,115	377
JULY										
New England	$0.50	$0.79	$0.55	$0.87	$1.16	$1.14	$0.84	$0.59	4,096	......
Middle Atlantic	.47	.80	.51	.81	1.07	.82	.77	.53	5,470	99
East North Central	.37	.66	.41	.64	.75	.80	.61	.47	4,522	......
West North Central	.37	.73	.42	.69	.92	.55	.58	.45	8,348	......
South Atlantic	.30	.72	.36	.53	.88	.60	.50	.34	1,259	126
East South Central	.25	.65	.33	.45	.91	.43	.51	.28	3,460	......
West South Central	.30	.62	.38	.57	.72	.60	.55	.38	1,836	......
Mountain	.45	.73	.54	.56	.95	.50	.75	.49	2,020	......
Pacific	.54	.92	.67	.93	1.13	.96	.93	.65	1,623	197
United States	.39	.73	.46	.70	.98	.74	.68	.46	32,634	422

Kind of Labor / Geographical Divisions	Common Labor	Foremen	Truck Drivers	Mixer Operators	Steam Shovel Operators	Structural Steel Workers	Carpenters	Concrete Labor	Total Number Men Employed	Convicts Employed
AUGUST										
New England	$0.49	$0.80	$0.54	$0.90	$1.15		$0.88	$0.58	4,043	......
Middle Atlantic	.47	.80	.51	.80	1.07	$0.88	.77	.53	6,699	30
East North Central	.38	.66	.43	.64	.72	.70	.61	.49	4,832	......
West North Central	.37	.74	.41	.70	.87	....	.60	.46	8,597	......
South Atlantic	.27	.56	.34	.55	.86	....	.51	.40	767	82
East South Central	.26	.65	.33	.45	.91	.55	.51	.28	3,831	......
West South Central	.28	.59	.35	.49	.73	....	.61	.33	1,409	......
Mountain	.46	.78	.55	.59	.96	.75	.75	.48	2,230	......
Pacific	.54	.97	.64	.92	1.16	1.00	.88	.65	1,667	180
United States	.40	.74	.46	.70	.96	.74	.69	.47	34,075	292
SEPTEMBER										
New England	$0.49	$0.80	$0.54	$0.85	$1.13	$0.94	$0.89	$0.58	4,266	......
Middle Atlantic	.46	.82	.51	.84	1.06	.71	.80	.54	6,621	94
East North Central	.40	.65	.44	.73	.76	.61	.63	.51	3,918	......
West North Central	.38	.74	.42	.64	.93	.69	.59	.46	8,121	......
South Atlantic	.26	.57	.30	.56	.68	....	.51	.36	731	200
East South Central	.25	.64	.33	.52	.87	.60	.49	.29	4,299	......
West South Central	.33	.73	.38	.72	.82	.60	.57	.46	1,704	......
Mountain	.46	.77	.53	.60	.93	....	.68	.48	2,026	......
Pacific	.54	.92	.64	.85	1.14	.80	.91	.54	1,610	140
United States	.40	.74	.47	.78	.97	.72	.68	.48	33,296	434
OCTOBER										
New England	$0.48	$0.77	$0.48	$0.89	$1.07	$0.58	$0.81	$0.59	2,908	......
Middle Atlantic	.46	.81	.52	.82	1.00	.90	.78	.54	4,520	......
East North Central	.40	.66	.46	.65	.77	.55	.64	.49	3,718	......
West North Central	.38	.71	.43	.63	.95	.67	.57	.44	7,518	......
South Atlantic	.28	.59	.27	.58	.90	....	.58	.37	372	18
East South Central	.25	.67	.32	.48	.89	.50	.50	.28	5,243	......
West South Central	.32	.71	.38	.68	.78	.55	.64	.44	2,415	......
Mountain	.48	.76	.56	.72	.93	.66	.79	.53	2,906	......
Pacific	.56	1.01	.66	.93	1.18	.88	.94	.65	1,741	164
United States	.40	.74	.48	.73	.96	.66	.69	.47	31,341	182
NOVEMBER										
New England	$0.48	$0.78	$0.49	$0.83	$1.10	$1.19	$0.81	$0.54	1,615	......
Middle Atlantic	.46	.82	.52	.77	1.05	1.00	.77	.55	3,387	95
East North Central	.40	.68	.45	.63	.81	.55	.65	.55	1,738	......
West North Central	.37	.73	.44	.62	.96	....	.61	.43	3,923	......
South Atlantic	.26	.59	.31	.43	.80	....	.55	.35	681	74
East South Central	.25	.66	.33	.47	.87	.42	.52	.32	5,189	......
West South Central	.30	.67	.35	.66	.78	....	.61	.36	2,201	......
Mountain	.47	.76	.57	.93	.99	.75	.75	.49	2,820	44
Pacific	.53	1.04	.64	.80	1.18	.75	.94	.68	1,548	......
United States	.40	.75	.47	.66	.98	.69	.70	.47	23,102	213
DECEMBER										
New England	$0.55	$0.86	$0.58	$0.70	$1.17		$0.87	$0.60	575	......
Middle Atlantic	.46	.77	.49	.75	1.00		.87	.55	200	......
East North Central	.42	.84	.45	....	.91		.87	.49	333	......
West North Central	.37	.68	.37	.50	.97	$0.72	.64	.44	738	......
South Atlantic	.24	.48	.32	....	....	....	.40	.25	176	77
East South Central	.24	.65	.31	.45	.82	.49	.49	.31	3,451	......
West South Central	.32	.78	.35	.87	.88	.80	.72	.49	787	......
Mountain	.46	.80	.60	.62	1.01	1.00	.85	.38	638	......
Pacific	.54	1.01	.67	.83	1.18	.75	.93	.56	1.014	23
United States	.39	.77	.47	.61	.97	.66	.68	.44	7,912	100

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The equipment prices have been revised. Some of the material in the old book is omitted and about twice as much material as made up the old book has been added, so that this new book is about three times as large in content as its predecessor.

Continued on Next Page

Earthwork and Its Costs *by Halbert P. Gillette*—Third edition, 1,346 pages, pocket size, flexible, illustrated. Price $6.00.

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With the exception of Cost Keeping and Management Engineering, this is the first book ever published on the subject of cost keeping on construction work. Its authors are pioneers in the field, and, although they have written much that has appeared in the form of articles—particularly in the pages of Engineering and Contracting—this book is the first presentation on the subject in a complete and logical sequence.

In the opening chapter the authors endeavor to reduce the management of men to a science, by laying down ten fundamental laws of management, each of which is fully discussed.

The second chapter contains 17 fundamental rules for securing minimum cost. These two chapters are wholly novel and of far reaching importance to all men who are, or hope to be, in charge of other men.

The authors then proceed to describe and illustrate their own systems of cost keeping, which they had developed on their own contract work and have also installed on the work of other contractors, giving both the punch card reports (a form of report which they were the first to devise) and the more common blanks to be filled in with pencil.

The last two chapters contain numerous systems of cost keeping developed by other engineers and contractors, and is a veritable mine of suggestive hints as well as of examples of excellent blanks for special purposes.

Contents. I.—Laws of Management. II.—Rules for securing mimimum costs. III.—Piece-Rate, Bonus and Other Systems of Payment. IV.—Measuring the Output of Workmen. V.—Cost Keeping. VI.—Cost Keeping as Applied to Highway Construction. VII.—Bookkeeping for Small Contractors. VIII.—Office Appliances and Methods. IX.—Miscellaneous Cost Report Blanks and Systems of Cost Keeping. X.—Systems of Cost Keeping.

Handbook of Clearing and Grubbing *by H. P. Gillette*—241 pages, 4¾"x7¼", illustrated. Price $2.50.

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Continued on Next Page

Augers and Cost Data. VIII.—Core Drills. IX.—Explosives. X.—Charging and Firing. XI.—Methods of Blasting. XII.—Loading and Transporting Rock. XIII.—Quarrying Dimension Stone. XIV.—Open Cut Excavation in Quarries, Pits and Mines. XV.—Railroad Rock Excavation and Boulder Blasting. XVI.—Canal Excavation. XVII.—Trench Work. XVIII.—Sub-Aqueous Rock Excavation.

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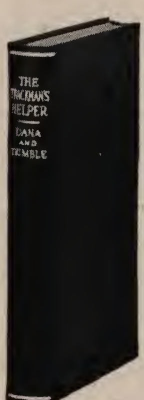

The Trackman's Helper *by R. T. Dana and A. F. Trimble*, after the original by J. Kindelan. 1917 edition, revised and enlarged. 401 pages, 4½"x6¾", illustrated. Price $2.50.

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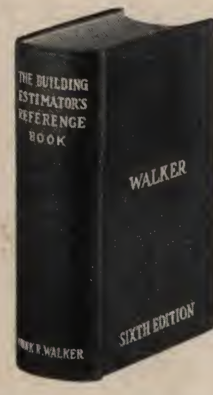

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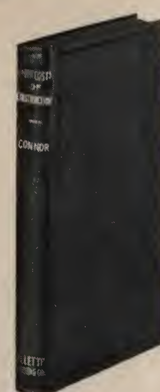

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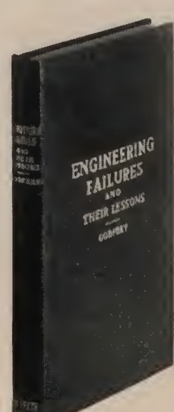

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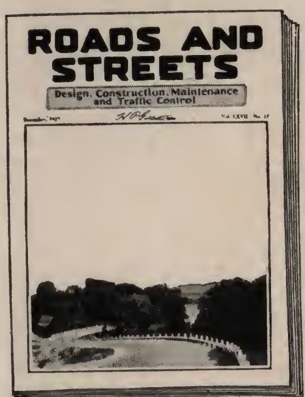
Continued on Next Page

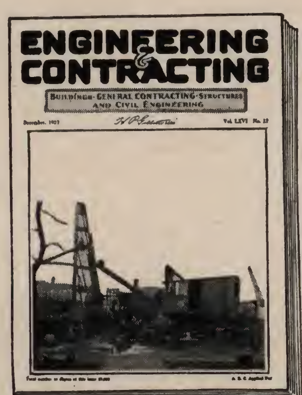
Any engineer or contractor will find in it many unbelievable disclosures, and challenging declarations which will stimulate thought along the most constructive lines.

Here is a significant quotation: "When anything offensive is found in a bee hive which the bees cannot remove, it is covered up with beeswax. Professional beeswax is very frequently and freely applied, when a structural wreck occurs, to obscure the ugly fact that the failure is due to the design, and the design is very often the standard, accepted design for which the leaders of the profession are responsible."



"Roads and Streets"—A monthly magazine edited by Mr. H. P. Gillette, Editor-in-Chief, Mr. C. T. Murray, Managing Editor and Staff. The subscription price is $2.00 per year. This magazine is a monthly sequel to Mr. Gillette's books. It contains the latest "methods and costs" on highway construction and maintenance and information on the latest developments in machinery and materials. The reading matter in one year's subscription to this magazine will amount to 3,000 pages of the size of a handbook, 4½"x7". The articles are all practical and bring to the road and street engineer and contractor useful and up to date information.

"Engineering and Contracting"—A monthly magazine edited by Mr. H. P. Gillette, Editor-in-Chief' Mr. C. T. Murray, Managing Editor and Staff. The subscription price is $2.00 per year.



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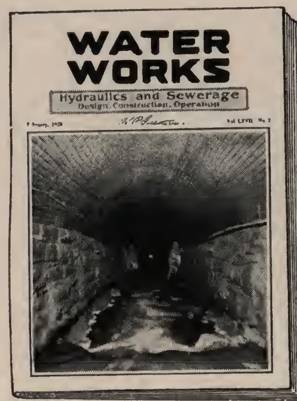

completes the monthly sequel to Mr. Gillette's books in the civil engineering and construction field. It contains the latest "methods and costs" on water works practice together with articles on the design, maintenance and operation of water works systems.

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Construction Equipment Schedule Showing Annual Expense

From a Report Compiled by the Associated General Contractors of America

Equipment expenses as here treated concern only ownership and maintenance, and do not include the cost of loading, shipping, erecting, operating, or dismantling for any particular construction project. The analysis of this ownership expense is condensed into a Construction Equipment Schedule, shown herewith.

The various columns of this schedule show specific items of expense for the individual machines listed and give for each item a value expressed in percent of the owner's capital investment. This investment is considered as the original cost of the machine at the contractor's initial unloading or receiving point, assembled, tested and ready for use. All net percentages shown in the schedule are based upon actual cost, and represent no element of profit or return sufficient to justify continuous reinvestment of funds in construction equipment. Items include no allowance for fuel, lubricants, supplies, transportation or crew wages, no portion of the owner's general expense of doing business and no allowance for risk of less than the average amount of annual equipment employment.

The Seven Items of Expense constituting equipment ownership an maintenance costs are: (1) depreciation, derived from the economical life of the machine; (2) interest on the investment; (3) major or shop repairs; (4) minor or field repairs; (5) storage, incidentals and equipment overhead; (6) insurance, and (7) taxes. These items and also the last two columns of the schedule showing average months of operation per year and expense per working month are subject respectively to the following definitions and explanations:

The Economical Life in Years (shown in column 2 of the Schedule) assumes the usual actual operating, repair and idle time during and between operation periods or construction jobs.

Depreciation (column 3 of the schedule) is considered as the loss of original usefulness beyond the ability of repairs to correct, and which eventually necessitates complete replacement. It is the loss resulting from wear and tear, and frequently from obsolescence. Obsolescence implies that the implement may become out of date or be superseded by a more modern and efficient product, thus necessitating premature scrapping of the original machine in order to meet competition in business.

The values for depreciation are based upon operation under the wear and tear of ordinary job conditions where the personnel of operating crews frequently changes, where handling even under the best field conditions is not uniform and where it is frequently not feasible to protect equipment from the weather. Depreciation is figured by the straight line method, in which a uniform percentage is set up each year throughout the life of the equipment and without allowing any salvage value, but considering a normal credit or scrap value in establishing the number of years of economical life.

Interest on Investment (column 4), is computed from the average cost of obtaining money by contractors for the purchase of equipment. Money may be borrowed from a bank on short time bank loans, with allowance for initial deduction of note interest and requirement for minimum bank balance of the amount loaned; or the equipment may be secured by monthly equipment notes of the manufacturer. Seven per cent is taken as an average rate, against which is credited 2 per cent for interest on depreciation reserves and other possible daily bank balances, leaving an average net interest charge of 5 per cent.

The table of percentage values given below represents for individual construction machines the annual expense of equipment ownership and maintenance, expressed in terms of original capital investment. To use these values with safety, it is necessary to understand the explanation which is given in the accompanying text.

Equipment	Economical Life, Years	Annual Expense, Per cent of Capital Investment: Depreciation	Interest	Major or Shop Repairs	Minor or Field Repairs	Storage Incidentals, Equip., Overh'd	Insurance	Taxes	Total	Average Use Months, per Year	Expense Per Working Month, Per cent
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Auto-crane, Gas	5	20	5	8	6	4	1	1	45	8	5.6
Auto-crane, Steam	6	17	5	8	5	4	1	1	41	8	5.1
Auto-truck	3	33	5	16	16	4	1	1	76	10	7.6
Auto-trailer	5	20	5	6	6	4	1	1	43	9	4.7
Backfiller, power	4	25	5	6	6	4	1	1	48	6	8.0
Ballast spreader	8	13	5	6	4	4	1	1	34	6	5.6
Boiler, upright	8	13	5	20	5	4	1	1	49	6	8.1
Boiler, locomotive	8	13	5	15	5	4	1	1	46	6	7.6
Bucket, clamshell	4	25	5	15	6	4	1	1	57	8	7.1
Bucket, orange-peel	4	25	5	25	6	4	1	1	67	7	9.6
Bucket, drag-line	4	25	5	12	4	4	1	1	52	6	8.6
Cars, steel dump	6	17	5	8	4	4	1	1	40	7	5.7
Cars, wood dump	5	20	5	10	5	4	1	1	46	7	6.5
Cars, flat	8	13	5	6	4	4	1	1	34	7	4.8
Cars, hopper	5	20	5	10	4	4	1	1	45	7	6.4
Compressor, steam	7	14	5	6	4	4	1	1	35	7	5.0
Compressor, gasoline	6	17	5	6	8	4	1	1	42	7	6.0
Compressor, electric	7	14	5	5	4	4	1	1	34	7	4.8
Concrete chutes	2	50	5	10	15	4	1	1	86	9	9.6
Conveyor, belt	2	50	5	6	10	4	1	1	77	8	9.6
Conveyor bucket, portable	3	33	5	10	6	4	1	1	60	7	8.5
Crusher, rock, portable	5	20	5	10	4	4	1	1	45	6	7.5
Derrick, wood	5	20	5	4	4	4	1	1	39	6	6.5
Derrick, steel	8	13	5	4	3	4	1	1	31	6	5.1
Drag-line, steam	6	17	5	8	8	4	1	1	44	8	5.5
Drag-line, gasoline	5	20	5	8	10	4	1	1	49	8	6.1
Drag-line, electric	6	17	5	8	8	4	1	1	44	8	5.5
Drill, tunnel carriage	5	20	5	8	8	4	1	1	47	8	5.8
Drill, traction well	6	17	5	7	10	4	1	1	45	8	5.6
Drill, tripod	4	25	5	7	10	4	1	1	43	9	4.7
Drill, jack hammer	2	50	5	5	15	4	1	1	81	9	9.0
Engine, gas	5	20	5	7	10	4	1	1	48	8	6.0
Engine, steam without boiler	10	10	5	5	5	4	1	1	31	8	3.8
Excavator, cableway complete	5	20	5	4	12	4	1	1	47	9	5.2
Excavator, trench, steam	6	17	5	8	4	4	1	1	40	9	4.4
Excavator, trench, gas	5	20	5	8	10	4	1	1	49	9	5.4
Forms, steel concrete	2	50	5	5	10	4	1	1	76	8	9.5
Graders, common road	4	25	5	12	6	4	1	1	54	10	5.4
Graders, elevating	4	25	5	15	9	4	1	1	60	10	6.0
Hoist, steam	8	13	5	6	4	4	1	1	34	9	3.7
Hoist, gasoline	6	17	5	7	8	4	1	1	43	9	4.7
Hoist, electric	8	13	5	6	4	4	1	1	34	9	3.7
Locomotive, Industrial steam	8	13	5	8	6	4	1	1	38	9	4.2
Locomotive, Industrial gas	5	20	5	10	10	4	1	1	51	9	5.6
Locomotive, Industrial battery	4	25	5	8	12	4	1	1	56	9	6.2
Locomotive, Standard gauge	10	10	5	8	6	4	1	1	35	10	3.5
Locomotive crane, steam	8	13	5	8	4	4	1	1	36	10	3.6
Locomotive crane, gas	7	14	5	8	8	4	1	1	41	10	4.1
Mixer, steam	5	20	5	10	6	4	1	1	47	8	5.8
Mixer, gasoline	4	25	5	10	10	4	1	1	56	8	7.0
Mixer, electric	5	20	5	10	6	4	1	1	47	8	5.8
Mixer, paving, steam	5	20	5	12	6	4	1	1	49	6	8.1
Mixer, paving, gas	4	25	5	12	10	4	1	1	58	6	9.6
Motors	6	17	5	6	4	4	1	1	38	8	4.7
Pile driver, steam	8	13	5	8	6	4	1	1	38	6	6.3
Pile driver, track	10	10	5	8	4	4	1	1	33	6	5.5
Pile hammer, steam	6	17	5	10	5	4	1	1	43	6	7.1
Pipe, galvanized	3	33	5	0	10	4	1	1	54	8	6.7
Plows	3	33	5	15	10	4	1	1	69	10	6.9
Pneumatic concrete machine	4	25	5	20	8	4	1	1	64	7	9.1

CONSTRUCTION EQUIPMENT SCHEDULE—PART I

Major or Shop Repairs (column 5), include those items of heavy repair which usually keep the machine idle for an extended period in contrast with the minor field repairs entailing little delay and necessary merely to keep the machine in operation. Included also in the item of major repairs is the cost of overhauling, at the contractor's shop or yard, necessary to maintain the equipment up to its best operating efficiency. These repairs do not include rebuilding to the extent of recovering efficiency lost through ordinary wear and tear. "Wear and tear" is defined as that uniform wear out and decay which repairing is unable to check and which is dependent upon the amount of use, the amount of care, the quality of materials and workmanship, and the natural hardships inherent in construction work.

Major repairs include both labor and material.

Minor or Field Repairs (column 6), include those repairs necessary to keep the machine in operation while on the job. This item includes material only since the labor of applying the repairs is generally considered part of the job expense and included in the job payroll. Provision for duplicate repair parts should be made in order to minimize expensive field delays as much as possible. Particular attention should be given to insure a ready supply of such pinions, sprocket wheels, chain, cable, bearings and other rapidly wearing members as experience and good practice dictate.

Storage, Incidentals and Overhead (column 7), are intended to include the expense of storing equipment between successive jobs or operations. These costs are made up of such items as rental and maintenance of storage site, warehouse or yard with wages of watchman, and the direct overhead chargeable to provision of storage facilities and renting of the particular item of equipment. Items of the contractor's general expense of doing business are not included, but under certain conditions, elsewhere explained, may be properly added.

Insurance (column 8), includes the average cost of premiums on the general policies covering fire, boiler and theft not written for a specific job. In the case of marine equipment, the additional premium for marine insurance is included. This insurance item does not include insurance, or losses not covered by insurance, while equipment is on a job, and for which the job is to be responsible, unless provision is otherwise made.

Each job should be charged, whether or not that job is covered by insurance, for surplus value not covered by insurance, as well as for losses to equipment and vessels which may be occasioned by water action, collision, storm, grounding, bumping, ice drift, fire, theft, or damage from other causes.

Taxes (column 9), are the average personal tax on assessed valuation of equipment and include corporation taxes on capital value of equipment, but do not include State or United States income taxes which are more properly items of general expense.

Average Use in Months Per Year (column 11), is based on the average yearly operating periods over a range of years under the normal climatic conditions usually prevailing in the latitude and altitude of the Central States. These periods which will vary in mountainous country or in the extreme northern and southern latitudes, are also based upon normal business conditions. The number of months of average use of equipment per year seems to the editor to have been considerably overestimated. Certainly for road work in the northern states not more than about half the number of months given in column (11) can be averaged. However, as an offset, it should be said that the "economical life," given column (12) is about half the actual life attained by many classes of equipment. Thus, steam road rollers are assigned a life of 8 years, whereas many steam rollers more than 25 years of age are still in use.—Editor.)

Expense Per Working Month (column 12), is the

Items of Equipment	Economical Life, Years	Annual Expense, Per cent of Capital Investment: Depreciation	Interest	Major or Shop Repairs	Minor or Field Repairs	Storage Incidentals, Equip., Overh'd	Insurance	Taxes	Total	Average Use in Months, Per Year	Expense Per Working Month, Per cent
Pump, centrifugal	5	20	5	6	4	4	1	1	41	6	6.8
Pump, piston	5	20	5	7	5	4	1	1	43	6	7.1
Pump, impulse	8	13	5	2	4	4	1	1	30	6	5.0
Rails	5	20	5	0	5	4	1	1	36	9	4.0
Riveter, air	2	50	5	10	10	4	1	1	81	10	8.1
Rock channeler	6	17	5	8	8	4	1	1	44	6	7.3
Roller, steam road	8	13	5	6	6	4	1	1	36	7	5.1
Roller, gas road	7	14	5	8	10	4	1	1	43	7	6.1
Saw Rigs	4	25	5	10	15	4	1	1	61	8	7.6
Scraper, wheel	3	33	5	8	4	4	1	1	56	9	6.2
Scraper, slip	2	50	5	25	10	4	1	1	96	10	9.6
Scraper, fresno	3	33	5	25	15	4	1	1	84	9	9.3
Shovel, steam	6	17	5	8	6	4	1	1	42	10	4.2
Shovel, gasoline	5	20	5	10	10	4	1	1	51	10	5.1
Shovel, electric	6	17	5	8	6	4	1	1	42	10	4.2
Switches, fabricated	3	33	5	5	5	4	1	1	54	9	6.0
Tower, steel hoist	7	14	5	5	5	4	1	1	35	8	4.3
Tractor, steam	6	17	5	8	6	4	1	1	42	10	4.2
Tractor, gas	5	20	5	8	10	4	1	1	49	10	4.9
Wagons, dump	4	25	5	14	6	4	1	1	56	10	5.6
Wagons, hauling	4	25	5	12	4	4	1	1	52	10	5.2
Wagon loaders, power, bucket or belt	5	20	5	10	6	4	1	1	47	9	5.2
MARINE EQUIPMENT											
Coastwise Craft											
Derrick boats	10	10	5	5	3	5	5	1	34	8	4.2
Dredge, clamshell	12	8	5	4	2	5	5	1	30	8	3.7
Dredge, dipper	8	12	5	12	4	5	5	1	44	8	5.5
Dredge, hydraulic	10	10	5	5	2	5	5	1	33	9	3.6
Drill Boats	12	8	5	8	3	5	7	1	37	10	3.7
Lighters	10	10	5	6	2	5	5	1	34	10	3.4
Pile Drivers	8	12	5	5	3	5	5	1	36	8	4.5
Scows	12	8	5	4	2	5	5	1	30	10	3.0
Scows, dump	8	12	5	8	3	5	5	1	39	8	4.8
Tugs	10	10	5	10	3	5	5	1	39	10	3.9
Inland Craft											
Barges, wooden	8	12	5	4	4	5	4	1	35	8	4.3
Barges, steel	12	8	5	3	3	5	4	1	29	10	2.9
Derrick Boats	7	14	5	6	5	5	4	1	40	8	5.0
Dredges, clamshell	7	14	5	6	5	5	4	1	40	8	5.0
Dredges, dipper	6	16	5	4	5	4	4	1	39	9	4.3
Dredges, hydraulic	10	10	5	5	4	4	4	1	33	9	3.6
Grader, hydraulic	7	14	5	4	4	5	4	1	37	8	4.6
Launches, gasoline	6	16	5	10	6	5	4	1	47	9	5.2
Pile Drivers	7	14	5	6	5	5	4	1	40	7	5.7
Quarter Boats	10	10	5	4	4	5	4	1	33	9	3.6
Rowboats	5	20	5	10	3	5	4	1	48	10	4.8
Steamers, paddle wheel	16	6	5	10	10	5	4	1	41	9	4.5
Tugs, screw propelled	16	6	5	10	6	5	4	1	37	10	3.7

CONSTRUCTION EQUIPMENT SCHEDULE—PART II

total annual expense in column 10 divided, not by twelve, but by the average use in months per year shown in column 11. This item should be carefully considered, either in estimating equipment expense for the contractor's own job or determining rational rental charges to other parties.

The items of expense per operating month are based on calendar months without deductions for holidays, on periods between shipment bills of lading, and on operating days not exceeding ten hours, justifying an expense charge per hour for overtime of about 4 per cent of the daily rate.

The above items of expense are based upon release of equipment, in as good condition as when sent to a job, subject to ordinary wear and tear proportionate to the time on the job. It is presumed, that job superintendents will give the home office a month's notice previous to releasing equipment, in order to permit allottment or placement elsewhere and thus tend to reduce idle time to a minimum.

Caution is necessary in arbitrarily using percentages such as those given in the Schedule. There may be some danger in applying these percentages to particular cases unless the conditions under which the equipment is to work are carefully investigated.

To illustrate.—If the values here given for a standard gauge railway steam shovel outfit were applied to such an outfit in the north, engaged constantly in excavating hard rock, the probability is that the charges would not cover the expense. Frequent dobey shots and the dropping of heavy boulders or frozen material into cars entail a higher rate of depreciation and repairs than is given in the schedule. On the other hand, if this shovel outfit were steadily engaged in the south or along the Pacific Coast in digging sandy loam, the values given in the table would probably cause the equipment charge to contain an element of profit.

Such a schedule merely sums up the experience of typical firms, and its value to others depends upon the individual judgment used in interpreting it in the light of circumstances surrounding any particular job, and in applying to it the local "experience rating" developed through recent successive years.

Depreciation Charges on Road Building Equipment

According to *Engineering and Contracting*, the regulations governing work of the State Highway Department of Arizona provided that upon completion of a project depreciation should be charged to the project, the equipment being rated on the following basis:

	Per cent per year
Engines, gas and steam	20
Fresnos	100
Graders	20
Mixers, concrete	20
Mules	10
Pile drivers	20
Plows	20
Rock crushers	20
Steam shovels	10
Tents	75
Wagons	20
Wheelbarrows and concrete carts	50

Trucks on daily rate on basis of life of three years. All small equipment such as picks, axes, shovels, etc., on value at time of transfer to new project. The following data are from *Engineering and Contracting*.

With the exception of mules, the life of the equipment is not solely dependent on the lapse of time. The length of the road building season, the continuity of the work and the care given in handling and maintenance, are all important factors in determining the life.

As for tents, it is not unusual to have them whipped to ribbons by strong winds in three months or less. On the other hand, if used only in dry weather, and where winds are not high, a tent may last several road building seasons.

In this connection it seems wise to point out that annual depreciation rates, such as those above given, are often assumed to include current repair costs, although usually the depreciation rate is intended to relate solely to the loss of life of the entire machine and not to loss of life of its parts. Railway locomotives, for example, have had an average life of about 25 years, or a straight-line depreciation rate of 4 per cent per year, assuming no scrap value. But the current repairs on railway locomotives have averaged about 18 or 20 per cent per annum.

Apparently the rates of annual depreciation above given do not include current repairs. Yet, if not, why is the annual depreciation of a steam engine put as high as 20 per cent? A steam engine will surely last as long as a steam shovel, yet the latter is given a depreciation rate of 10 per cent.

The fact is that not a great deal has been published on the lives and maintenance costs of construction equipment. Dana's "Handbook of Construction Plant" gives data on this subject. The startling fact is brought out there that for one year (1908) repairs on steam shovels on the Panama Canal amounted to nearly 50 per cent of their first cost! This was equivalent to nearly 3 cts. per cubic yard excavated. This, of course, was under unusually expensive conditions and where the work was continuous. Dana puts the average life of a steam shovel at 20 years.

In calculating depreciation and repairs, it is usually desirable to separate the two. Estimate depreciation for the full years, but estimate repairs by the month of actual work. Thus, in the case of a steam shovel, the annual depreciation may be estimated at 6 per cent, and the repairs may be estimated at 2 per cent per month of single-shift work. Then if it is estimated that the shovel will actually work six months during a year, the depreciation amounts to 1 per cent and the repairs 2 per cent per month of actual work.

Roadbuilding equipment averages less than 6 months' actual work in the northern states—probably about 4 months. This runs up the interest and depreciation charges per month of actual work. Thus, with annual interest at 6 per cent and depreciation at 12 per cent, we have 18 per cent for the year, or 4.5 per cent per working month if charged entirely against the working time. Add to this, say, 2.5 per cent for repairs, and we have a total of 7 per cent per working month for interest, depreciation and repairs.

Many a road building contractor has "gone broke," and many a highway engineer has erred grievously in his cost estimates, through failure to estimate correctly fixed charges and repairs on road building equipment. Add to this sort of underestimate one or two others of similar nature, and we have an almost complete explanation of why a new crop of road-building contractors buds forth each spring only to wither permanently each autumn.

Economic Uses of Bucket Loader

Application of the bucket loader in handling materials for the construction of concrete pavements on city streets and country roads were described as follows in *Roads and Streets* by J. E. Marson:

Application of Bucket Loader in City Paving.—In the city of Chicago it is not permissible to place material on the sub-grade and as a result the supply companies deliver sand and stone and cement to the contractor at the street intersections. They deliver it as it is required and the contractor can generally estimate his deliveries so close that when he finishes each block on these streets there is very little material left on the ground. What little material there is left the bucket loader will pick up and put into a truck to carry it to the next intersection. Or, if required, sufficient material may be stored at each intersection to take care of the preceding blocks.

The paver starts in at the intersection preceding; one loader is placed on sand and one on stone; a small platform, which is designed to carry a truck load or two of cement, is placed right near them, and your paving operation is ready to start. Three or four light trucks are used to haul one batch per truck from the intersection to the paver. The truck dumps its batch into the paver, comes back to the stone loader, receives its batch of stone, goes to the sand loader, receives its batch of sand, swings around past the cement platform, receives its required sacks of cement, and goes back to the paver again. The time required for loading is generally less than one minute. It can easily be seen by the description of this method that practically all hand labor is eliminated. Each loader is operated by one man alone and practically the only men who are working are the three cement men. It is perhaps not necessary to have the three cement men, but most contractors have found it good policy to use three instead of two, so as to spell the other men on the cement.

Delivery of Material from Loader to Mixer.—Some contractors use horse carts instead of light trucks to carry the material from the loader to the mixer. This is generally a matter of personal opinion as to what one likes to use. It bears no direct relation to the efficient operation of the loaders themselves. As far as can be determined the cost of operation with horse carts and light trucks is very much the same. A small light 3-wheeled truck tractor has been used successfully for this transportation, and it has many features which make it worth while. The most distinct feature, of course, is the fact that it can turn around within its own radius without the necessity of backing up. This feature is especially valuable in alley work where the alleys run from 12 ft. to 14 ft. in width. In such a place it is generally necessary to back the light truck down the alley, and with the 4-wheeled truck tractor it is possible to run down and switch around very quickly.

Where it is possible to store material on the sub-grade the bucket loaders have worked out equally well. The materials, sand and stone, are piled along the sub-grade in parallel rows, in sufficient quantity per foot to build the pavement for the given length.

Again it is a question of personal opinion as to what method of transportation to use from the loader to the mixer. Some contractors are still sold on the proposition of using wheelbarrows to dump into the skip of the mixer. For that purpose a wheelbarrow hopper has been designed for the loader. The loaders pick the material off the grade and put it in the hopper. It is possible by the wheelbarrow method that the contractor requires only one loader for the stone and none for the sand.

It may be cheaper for him to wheel and shovel the sand into the skip of the mixer. The reason for this is that it is possible to hire men to shovel sand, and they will work fast enough and cheap enough to make it a paying proposition to use them for sand only. However, it is practically impossible to put men on stone, and their efficiency is generally so low that it is a very costly proposition. Go out on the job of any contractor who is using the wheelbarrow method, and in the morning you will find all the men clustered about the sand pile hoping they will not be put on the stone. The least number of men we have seen on a wheelbarrow gang for the stone is 9 men, 4 of them wheeling and shoveling and the other 5 just shoveling into the wheelbarrows.

If the contractor just wants to use one loader on the stone and eliminate his stone wheelers he can use a Ford truck or any light truck to shuttle back and forth between the stone loader and the skip of the mixer, in which case it is not necessary for the truck to turn around on the grade. In this case the sand would still be handled by a wheelbarrow gang. Or if he wants to eliminate all the wheelers he can take a 3-wheeled truck-tractor; generally only one is necessary if the mixer is not more than 40 ft. away from the sub-grade piles, and the sand would be shoveled into the tractor with the loader to batch the stone into it. Three men are generally all that are necessary for the sand shoveling. This method was used very successfully by the Brusstar Construction Co. of New York City.

Batching Material at Supply Yard.—If a contractor should happen to have a small city job and wanted to batch his material right at the supply yard this is perfectly possible with the bucket loader. Perhaps the best example of this method is the one used by the Spoor-Lasher Co., Poughkeepsie, N. Y. They have a material yard and they also lay concrete pavement. They place their two bucket loaders, one on sand and one on stone right in their material yard and batch the aggregate for their mixers with 2 and 3 batch trucks, besides supplying the retail trade and some of the mixers of their fellow contractors who were working near them.

It is a very simple proposition to figure whether a bucket loader is going to be a paying proposition to the contractor because you can estimate the cost of the loader at approximately $18 to $20 a day, that price assuming a 4-year depreciation and average labor conditions as at the present time.

Bucket Loader as Sub-grader.—There is also this added feature of the bucket loader for city work, that it is able to load any kind of material that is loose and broken up. This makes it particularly adaptable for sub-grading if the material is plowed or rooted up first. This plowing or rooting can be done either by teams or with a tractor hitched onto a rooter plow or a scarifier attached behind a steam roller. It has proved out that it is very economical to use a rooter with teams hitched to it, but with a steam roller with a scarifier attachment, unless the steam roller is for other use on the street, it is not a very economical proposition. This sub-grading has proved very successful up to about 20 in. in depth. Beyond that depth it is undoubtedly a steam shovel job. But even though a steam shovel has gone through on the work it generally

leaves considerable material which has to be shoveled into wagons or trucks. The loader can be used for this work much more efficiently and economically than hand labor.

In fact, any place where there is material to be loaded into vehicles and the material is loose, the bucket loader is a saving proposition. It has been used in cinders very extensively, besides gravel deposits and sand pits. It is equipped with hooks to which a chain can be attached to haul other machinery around and has plenty of power to do it. It has also been used in city work for backfilling of trenches, by contractors who had bid in the sewers as well as street paving.

Bucket Loaders on Highway Work.—As country and state highway work is practically the same, in that it is out in the country and is not affected by the same conditions as in the city, we will group them under one head. In the first place a state job means generally that the contractor has to develop his own material handling layout from the time the material arrives in the cars on the siding or is in the local pit until it is in the pavement as concrete. For unloading hopper bottom cars at the railroad siding a portable belt conveyor in lengths from 15 ft. to 60 ft. has been developed. This conveyor can be built in any length divisible by three between those two lengths in the portable style. It is built in two widths, namely 18 in. and 24 in. in either the plain belt or the cleated belt type. If the contractor buys, say a 33 ft. length, and at some future time wishes to have a 42-ft., it is only necessary for him to buy the 9-ft. section which will fit in and thus increase the length of his conveyor. This makes the conveyor a typical contractor's piece of equipment. The wheels are made so that they can swivel and turn at right angles to the conveyor so that it is possible to make a large semi-circular stock pile from the same unloading pit under the track.

It is necessary to build a pit under the track to load the hopper of the conveyor. This, however, is a simple job, costing very little, the main problem being to feed the material to the conveyor in a continuous stream. No belt conveyor should ever be started up under a dead load. This can easily be taken care of by an adjustable gate on the track hopper or by a baffle plate made of 2x4's and 2-in. planks so that when the hopper of the car is broken open the material hits this baffle and then slides around the side down onto the belt. A belt conveyor which is properly fed will last indefinitely.

Storage of Material.—Advance storage is absolutely necessary today if the contractor is going to keep his job moving. It is still permissible in some states to store the material on the subgrade and where this is possible the loaders are placed, one on sand, one on stone, on the grade with generally two, three or four trucks operating between them and the mixer. Some states specify that they be placed not closer than 600 ft. from the mixer. In other states the distance is 1,000 ft.

Roadside storage enables the contractor to start his paving at the end of his job farthest from the source of supply of his materials. During the grading the contractor can be storing his material at the first stock-piling point. By the time the grading has passed the stock-piling point, sufficient material is stock-piled to pave the road from the beginning of the job to that point. The contractor then starts his paving using light trucks from the stock pile to the paver with a bucket loader on sand and one on stone for the batching. At the same time his grading is going on from the first stocking point to the next, at which point the contractor is stock-piling the material sufficient for the distance between those two points. The trucks handling the material from the sidings to the stock-piling points are thus able to haul over a good road at all times and are not hauling over a green grade with resultant grief to the trucks. His paver is operating close to his source of supply, the paving superintendent has his job right under his finger ends, and he is practically free from all delays except heavy, rainy weather which must be wet enough to stop him from laying concrete.

If it should happen that the siding where the contractor unloads his material is in the center of his job and it seems more economical to batch and haul from that point to the mixer, the loaders are just as adaptable in that condition. The conveyor takes care of the unloading of the cars, the loaders do the batching.

For state work where the specifications are very strict as to the proportioning a strike-off hopper has been developed.

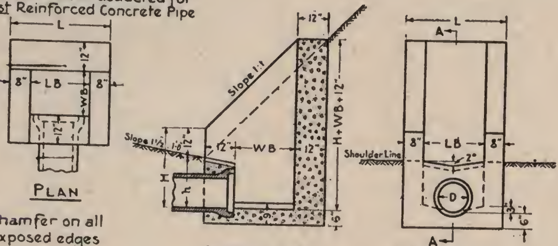
Transporting Material from Loader to Mixer.—Several contractors lean toward the horse cart type of transportation from the loader to the mixer. This system is quite efficient, and last year a user, August Kramp of Wisconsin, who uses this system entirely, gave an exhibition to the state Highway Department of Wisconsin, and for 12 hours operation he averaged a batch every minute and 20 seconds to his paver. When you consider it is a state specification to mix each batch at least a minute you can understand the efficiency of the system in delivering continuous batches to the mixer and eliminating delays. He used five horse carts to carry on this paving, the stock on the subgrade being about 300 ft. ahead of the mixer all the time and said that he could have used 4 carts and got away just as well. During this time he said there was a horse cart with a batch waiting each time the skip of the mixer came down.

The Troy Paving Co. likes 4-batch trucks. They made the record for the City of Troy, New York, last year, using two 4-batch trucks shuttling between the loader and the mixer. The loader was never hurried to keep up with them. The R. F. Conway Co. of Chicago used 3-batch trucks. They are probably the largest road contractors in the state of Illinois and have 10 loaders. They have used them the past year not only for batching aggregate but also for covering the pavement with the dirt from the shoulders. It is required that 2 in. of wet moist earth be placed on the pavement for a certain length of time necessary for curing. This generally has kept 6 men busy. Conway used the loader and two men did the job. They also used it for loading dirt from borrow pits and piles, as well as gravel, cinders and other bulk material.

End Walls

Standards of Pennsylvania State Highway Department

Volume has been deducted for Cast Reinforced Concrete Pipe



1" chamfer on all exposed edges

QUANTITIES IN ONE WALL

D = 12" PIPE

h	H	LB	WB	L	H+WB+12"	Cu.Yds.
1.67	2.67	2.0	2.0	3.33	5.67	1.644
2.00	3.00	2.0	2.0	3.33	6.00	1.758
2.50	3.50	2.0	2.0	3.33	6.50	1.930
3.00	4.00	2.0	2.0	3.33	7.00	2.103
3.50	4.50	2.0	2.0	3.33	7.50	2.276
4.00	5.00	2.0	2.0	3.33	8.00	2.449
4.50	5.50	2.0	2.0	3.33	8.50	2.622
5.00	6.00	2.0	2.0	3.33	9.00	2.794

D = 24" PIPE

h	H	LB	WB	L	H+WB+12"	Cu.Yds.
2.67	3.67	3.0	3.0	4.33	7.67	2.892
3.00	4.00	3.0	3.0	4.33	8.00	3.046
3.50	4.50	3.0	3.0	4.33	8.50	3.281
4.00	5.00	3.0	3.0	4.33	9.00	3.515
4.50	5.50	3.0	3.0	4.33	9.50	3.750
5.00	6.00	3.0	3.0	4.33	10.00	3.984
5.50	6.50	3.0	3.0	4.33	10.50	4.219
6.00	7.00	3.0	3.0	4.33	11.00	4.453

D = 15" PIPE

h	H	LB	WB	L	H+WB+12"	Cu.Yds.
2.00	3.00	2.0	2.0	3.33	6.00	1.733
2.50	3.50	2.0	2.0	3.33	6.50	1.905
3.00	4.00	2.0	2.0	3.33	7.00	2.078
3.50	4.50	2.0	2.0	3.33	7.50	2.251
4.00	5.00	2.0	2.0	3.33	8.00	2.424
4.50	5.50	2.0	2.0	3.33	8.50	2.597
5.00	6.00	2.0	2.0	3.33	9.00	2.770
5.50	6.50	2.0	2.0	3.33	9.50	2.942

D = 30" PIPE

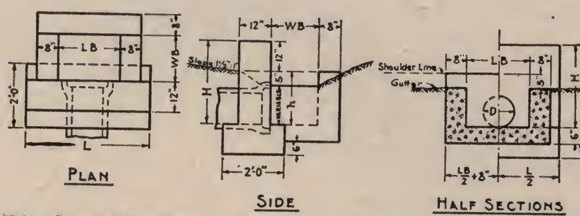
h	H	LB	WB	L	H+WB+12"	Cu.Yds.
3.17	4.17	3.5	3.5	4.83	8.67	3.642
3.50	4.50	3.5	3.5	4.83	9.00	3.817
4.00	5.00	3.5	3.5	4.83	9.50	4.083
4.50	5.50	3.5	3.5	4.83	10.00	4.348
5.00	6.00	3.5	3.5	4.83	10.50	4.613
5.50	6.50	3.5	3.5	4.83	11.00	4.879
6.00	7.00	3.5	3.5	4.83	11.50	5.144
6.50	7.50	3.5	3.5	4.83	12.00	5.409

D = 18" PIPE

h	H	LB	WB	L	H+WB+12"	Cu.Yds.
2.33	3.33	2.5	2.5	3.83	6.83	2.291
2.75	3.75	2.5	2.5	3.83	7.25	2.462
3.25	4.25	2.5	2.5	3.83	7.75	2.665
3.75	4.75	2.5	2.5	3.83	8.25	2.869
4.25	5.25	2.5	2.5	3.83	8.75	3.073
4.75	5.75	2.5	2.5	3.83	9.25	3.276
5.25	6.25	2.5	2.5	3.83	9.75	3.480
5.75	6.75	2.5	2.5	3.83	10.25	3.684

D = 36" PIPE

h	H	LB	WB	L	H+WB+12"	Cu.Yds.
3.67	4.67	4.0	4.0	5.33	9.67	4.477
4.00	5.00	4.0	4.0	5.33	10.00	4.672
4.50	5.50	4.0	4.0	5.33	10.50	4.969
5.00	6.00	4.0	4.0	5.33	11.00	5.265
5.50	6.50	4.0	4.0	5.33	11.50	5.561
6.00	7.00	4.0	4.0	5.33	12.00	5.857
6.50	7.50	4.0	4.0	5.33	12.50	6.154
7.00	8.00	4.0	4.0	5.33	13.00	6.450



1" chamfer on all exposed edges
Volume has been deducted for Cast Reinforced Concrete Pipe

QUANTITIES IN ONE WALL

D = 12" PIPE

h	H	L	WB	LB	Cu.Yds.
1.67	2.67	4.0	2.0	2.0	1.035
2.00	3.00	4.0	2.0	2.0	1.144
2.50	3.50	4.0	2.0	2.0	1.308
3.00	4.00	4.0	2.0	2.0	1.473
3.50	4.50	4.0	2.0	2.0	1.638
4.00	5.00	4.0	2.0	2.0	1.802
4.50	5.50	4.0	2.0	2.0	1.967
5.00	6.00	4.0	2.0	2.0	2.131

D = 24" PIPE

h	H	L	WB	LB	Cu Yds.
2.67	3.67	5.0	3.0	3.0	1.742
3.00	4.00	5.0	3.0	3.0	1.887
3.50	4.50	5.0	3.0	3.0	2.107
4.00	5.00	5.0	3.0	3.0	2.328
4.50	5.50	5.0	3.0	3.0	2.548
5.00	6.00	5.0	3.0	3.0	2.768
5.50	6.50	5.0	3.0	3.0	2.988
6.00	7.00	5.0	3.0	3.0	3.208

D = 15" PIPE

h	H	L	WB	LB	Cu.Yds.
2.0	3.0	4.5	2.25	2.0	1.247
2.5	3.5	4.5	2.25	2.0	1.426
3.0	4.0	4.5	2.25	2.0	1.606
3.5	4.5	4.5	2.25	2.0	1.786
4.0	5.0	4.5	2.25	2.0	1.966
4.5	5.5	4.5	2.25	2.0	2.146
5.0	6.0	4.5	2.25	2.0	2.327
5.5	6.5	4.5	2.25	2.0	2.507

D = 30" PIPE

h	H	L	WB	LB	Cu.Yds.
3.17	4.17	6.0	3.5	3.5	2.277
3.50	4.50	6.0	3.5	3.5	2.447
4.00	5.00	6.0	3.5	3.5	2.704
4.50	5.50	6.0	3.5	3.5	2.961
5.00	6.00	6.0	3.5	3.5	3.218
5.50	6.50	6.0	3.5	3.5	3.476
6.00	7.00	6.0	3.5	3.5	3.733
6.50	7.50	6.0	3.5	3.5	3.990

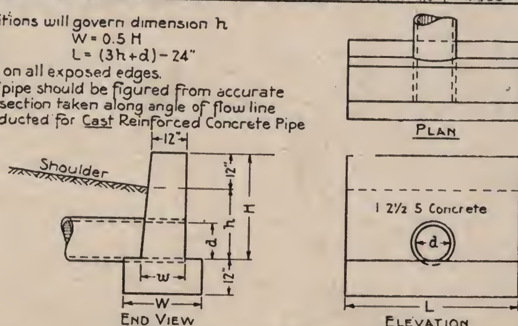
D = 18" PIPE

h	H	L	WB	LB	Cu.Yds.
2.33	3.33	5.0	2.5	2.5	1.526
2.75	3.75	5.0	2.5	2.5	1.696
3.25	4.25	5.0	2.5	2.5	1.897
3.75	4.75	5.0	2.5	2.5	2.099
4.25	5.25	5.0	2.5	2.5	2.301
4.75	5.75	5.0	2.5	2.5	2.502
5.25	6.25	5.0	2.5	2.5	2.704
5.75	6.75	5.0	2.5	2.5	2.906

D = 36" PIPE

h	H	L	WB	LB	Cu Yds.
3.67	4.67	7.0	4.0	4.0	2.876
4.00	5.00	7.0	4.0	4.0	3.070
4.50	5.50	7.0	4.0	4.0	3.364
5.00	6.00	7.0	4.0	4.0	3.658
5.50	6.50	7.0	4.0	4.0	3.953
6.00	7.00	7.0	4.0	4.0	4.247
6.50	7.50	7.0	4.0	4.0	4.541
7.00	8.00	7.0	4.0	4.0	4.835

Local conditions will govern dimension h
H = h + 12" W = 0.5 H
w = 0.4 h L = (3h + d) − 24"
1" chamfer on all exposed edges.
Length of pipe should be figured from accurate cross-section taken along angle of flow line
Volume deducted for Cast Reinforced Concrete Pipe



QUANTITIES IN ONE WALL

12" PIPE

h	H	L	Cu.Yds.
4.0	5.0	11.0	3.587
4.5	5.5	12.5	4.749
5.0	6.0	14.0	6.123
5.5	6.5	15.5	7.728
6.0	7.0	17.0	9.578
6.5	7.5	18.5	11.691

24" PIPE

h	H	L	Cu.Yds.
4.0	5.0	12.0	3.729
4.5	5.5	13.5	4.923
5.0	6.0	15.0	6.332
5.5	6.5	16.5	7.974
6.0	7.0	18.0	9.867
6.5	7.5	19.5	12.024
7.0	8.0	21.0	14.466
7.5	8.5	22.5	17.203

15" PIPE

h	H	L	Cu.Yds.
4.25	5.25	12.0	4.193
4.75	5.75	13.5	5.468
5.25	6.25	15.0	6.966
5.75	6.75	16.5	8.702
6.25	7.25	18.0	10.693
6.75	7.75	19.5	12.957

30" PIPE

h	H	L	Cu.Yds.
4.5	5.5	14.0	4.970
5.0	6.0	15.5	6.391
5.5	6.5	17.0	8.049
6.0	7.0	18.5	9.957
6.5	7.5	20.0	12.130
7.0	8.0	21.5	14.592
7.5	8.5	23.0	17.352
8.0	9.0	24.5	20.431

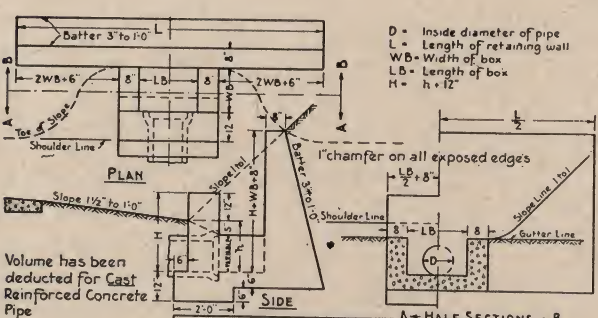
18" PIPE

h	H	L	Cu.Yds.
4.0	5.0	11.5	3.671
4.5	5.5	13.0	4.850
5.0	6.0	14.5	6.243
5.5	6.5	16.0	7.867
6.0	7.0	17.5	9.741
6.5	7.5	19.0	11.878
7.0	8.0	20.5	14.298

36" PIPE

h	H	L	Cu.Yds.
5.0	6.0	16.0	6.423
5.5	6.5	17.5	8.092
6.0	7.0	19.0	10.016
6.5	7.5	20.5	12.205
7.0	8.0	22.0	14.678
7.5	8.5	23.5	17.459
8.0	9.0	25.0	20.556
8.5	9.5	26.5	24.002

D = Inside diameter of pipe
L = Length of retaining wall
WB = Width of box
LB = Length of box
H = h + 12"



Volume has been deducted for Cast Reinforced Concrete Pipe

QUANTITIES IN ONE WALL

D = 12" PIPE

h	H	L	WB	LB	H+WB+8"	Cu Yds
1.67	2.67	10.33	1.5	2.0	4.83	3.398
2.00	3.00	10.33	1.5	2.0	5.16	3.720
2.50	3.50	10.33	1.5	2.0	5.66	4.229
3.00	4.00	10.33	1.5	2.0	6.16	4.762
3.50	4.50	10.33	1.5	2.0	6.66	5.319
4.00	5.00	10.33	1.5	2.0	7.16	5.900
4.50	5.50	10.33	1.5	2.0	7.66	6.504
5.00	6.00	10.33	1.5	2.0	8.16	7.133

D = 24" PIPE

h	H	L	WB	LB	H+WB+8"	Cu Yds
2.67	3.67	13.33	2.0	3.0	6.33	6.198
3.00	4.00	13.33	2.0	3.0	6.66	6.677
3.50	4.50	13.33	2.0	3.0	7.16	7.429
4.00	5.00	13.33	2.0	3.0	7.66	8.211
4.50	5.50	13.33	2.0	3.0	8.16	9.024
5.00	6.00	13.33	2.0	3.0	8.66	9.868
5.50	6.50	13.33	2.0	3.0	9.16	10.743
6.00	7.00	13.33	2.0	3.0	9.66	11.649

D = 15" PIPE

h	H	L	WB	LB	H+WB+8"	Cu Yds.
2.0	3.0	10.33	1.5	2.0	5.16	3.695
2.5	3.5	10.33	1.5	2.0	5.66	4.204
3.0	4.0	10.33	1.5	2.0	6.16	4.737
3.5	4.5	10.33	1.5	2.0	6.66	5.294
4.0	5.0	10.33	1.5	2.0	7.16	5.875
4.5	5.5	10.33	1.5	2.0	7.66	6.479
5.0	6.0	10.33	1.5	2.0	8.16	7.108
5.5	6.5	10.33	1.5	2.0	8.66	7.760

D = 30" PIPE

h	H	L	WB	LB	H+WB+8"	Cu Yds
3.17	4.17	15.83	2.5	3.5	7.33	8.901
3.50	4.50	15.83	2.5	3.5	7.66	9.516
4.00	5.00	15.83	2.5	3.5	8.16	10.479
4.50	5.50	15.83	2.5	3.5	8.66	11.479
5.00	6.00	15.83	2.5	3.5	9.16	12.515
5.50	6.50	15.83	2.5	3.5	9.66	13.588
6.00	7.00	15.83	2.5	3.5	10.16	14.698
6.50	7.50	15.83	2.5	3.5	10.66	15.844

D = 18" PIPE

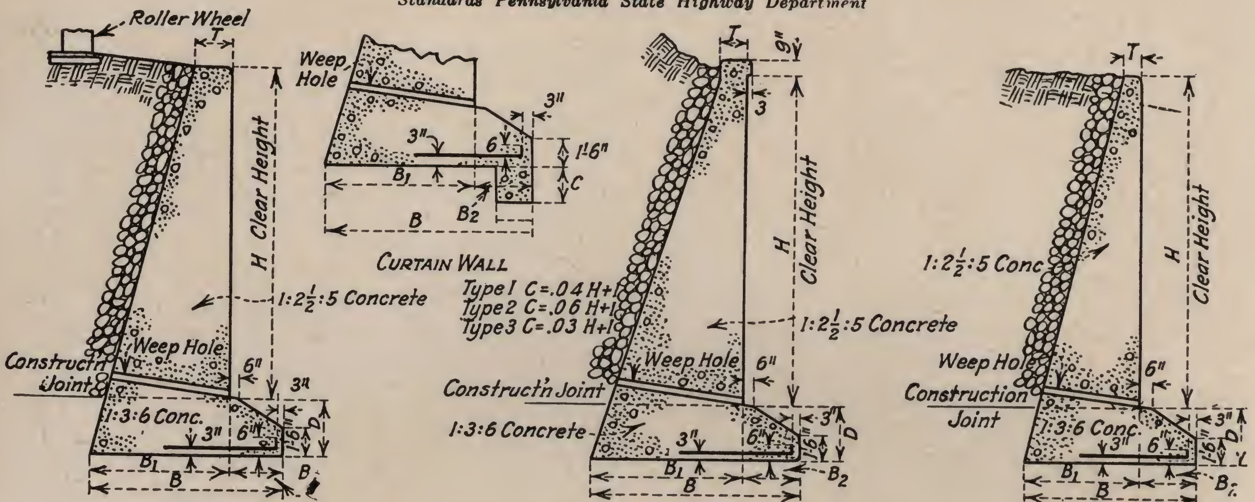
h	H	L	WB	LB	H+WB+8"	Cu Yds
2.33	3.33	12.83	2.0	2.5	5.99	5.503
2.75	3.75	12.83	2.0	2.5	6.41	6.072
3.25	4.25	12.83	2.0	2.5	6.91	6.776
3.75	4.75	12.83	2.0	2.5	7.41	7.510
4.25	5.25	12.83	2.0	2.5	7.91	8.273
4.75	5.75	12.83	2.0	2.5	8.41	9.066
5.25	6.25	12.83	2.0	2.5	8.91	9.889
5.75	6.75	12.83	2.0	2.5	9.41	10.742

D = 36" PIPE

h	H	L	WB	LB	H+WB+8"	Cu.Yds.
3.67	4.67	18.33	3.0	4.0	8.33	12.269
4.00	5.00	18.33	3.0	4.0	8.66	13.036
4.50	5.50	18.33	3.0	4.0	9.16	14.233
5.00	6.00	18.33	3.0	4.0	9.66	15.474
5.50	6.50	18.33	3.0	4.0	10.16	16.756
6.00	7.00	18.33	3.0	4.0	10.66	18.081
6.50	7.50	18.33	3.0	4.0	11.16	19.449
7.00	8.00	18.33	3.0	4.0	11.66	20.858

Retaining Walls

Standards Pennsylvania State Highway Department



Type 1. Type 2. Type 3.

TYPE 1—WALLS SUSTAINING ROADWAY AND 20-TON ROLLER WHEEL.

Clear Height H	Top Width T	Base B	B_1	B_2	Footing Depth—D	Reinforcement ¾" Round Bar	1:2½:5 Concrete per lin. ft. Cu.Yd.	1:3:6 Concrete per lin. ft. Cu.Yd.	Steel per lin. ft. Lb.	Toe Press per sq. ft. Lb.
2'	2'	3' 6"	2' 0"	1' 6"	2' 0"	....	.148	.250	......	.....
3'	2'	3' 9"	2' 2"	1' 7"	2' 0"	....	.228	.265	......	1150
4'	2'	4' 2"	2' 6"	1' 8"	2' 0"	....	.320	.292	......	1400
5'	2'	4' 10"	3' 0"	1' 10"	2' 6"	....	.432	.407	......	1700
6'	2'	5' 3"	3' 4"	1' 11"	2' 6"	....	.589	.442	......	1850
7'	2'	5' 8"	3' 8	2' 0"	2' 6"	....	.678	.476	......	2000
8'	2'	6' 2"	4' 0"	2' 2"	2' 6"	6' 0" lg., 2' 0" c-c.	.818	.519	4.506	2150
9'	2'	6' 7"	4' 4"	2' 3"	2' 6"	6' 0" lg., 2' 0" c-c.	.970	.554	4.506	2300
10'	2'	7' 3"	4' 10"	2' 5"	3' 0"	6' 3" lg., 2' 0" c-c.	1.152	.716	4.694	2600
11'	2'	7' 8"	5' 2"	2' 6"	3' 0"	6' 3" lg., 2' 0" c-c.	1.321	.759	4.694	2870
12'	2'	8' 1"	5' 6"	2' 7"	3' 0"	6' 3" lg., 2' 0" c-c.	1.511	.802	4.694	3140
13'	2'	8' 6"	5' 10"	2' 8"	3' 0"	6' 6" lg., 2' 0" c-c.	1.715	.845	4.882	3400
14'	2'	9' 0"	6' 2"	2' 10"	3' 0"	6' 6" lg., 2' 0" c-c.	1.926	.894	4.882	3670
15'	2'	9' 5"	6' 6"	2' 11"	3' 0"	6' 9" lg., 1' 8" c-c	2.153	.938	6.083	3900
16'	2'	9' 10"	6' 10"	3' 0"	3' 0"	6' 9" lg., 1' 4" c-c.	2.390	.981	7.604	4160
17'	2'	10' 3"	7' 2"	3' 1"	3' 0"	6' 9" lg., 1' 2" c-c.	2.645	1.025	8.690	4430
18'	2'	10' 8"	7' 6"	3' 2"	3' 0"	7' 0" lg., 1' 0" c-c.	2.905	1.068	10.514	4590
19'	2'	11' 2"	7' 10"	3' 4"	3' 0"	7' 0" lg., 11" c-c.	3.178	1.118	11.469	4760
20'	2'	12' 0"	8' 6"	3' 6"	4' 0"	7' 3" lg., 1' 5" c-c.	3.411	1.580	7.686	5300
21'	2'	12' 5"	8' 10"	3' 7"	4' 0"	7' 3" lg., 1' 1" c-c.	3.789	1.616	10.052	5500
22'	2'	12' 10"	9' 2"	3' 8"	4' 0"	7' 6" lg., 11" c-c.	4.092	1.674	12.289	5700
23'	2'	13' 4"	9' 6"	3' 10"	4' 0"	7' 6" lg., 9½" c-c.	4.421	1.739	14.229	5900
24'	2'	13' 9"	9' 10"	3' 11"	4' 0"	7' 9" lg., 8½" c-c.	4.764	1.796	16.434	6100
25'	2'	14' 2"	10' 2"	4' 0"	4' 0"	7' 9" lg., 7" c-c.	5.112	1.853	19.956	6300

TYPE 2—WALLS SUSTAINING SLOPING BANKS OF EARTH OF INDEFINITE HEIGHT.

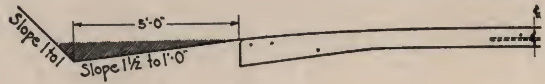
Clear Height H	Top Width T	Base B	B_1	B_2	Footing Depth—D	Reinforcement ¾" Round Bar	1:2½:5 Concrete per lin. ft. Cu.Yd.	1:3:6 Concrete per lin. ft. Cu.Yd.	Steel per lin. ft. Lb.	Toe Press per sq. ft. Lb.
2'	1' 6"	2' 0"	1' 6"	6"	2' 0"	....	.111	.148	......	1300
3'	1' 6"	2' 2"	1' 6"	8"	2' 0"	....	.167	.160	......	1644
4'	1' 6"	2' 6"	1' 6"	1' 0"	2' 0"	....	.222	.179	......	1975
5'	1' 6"	3' 6"	2' 2"	1' 4"	2' 6"	....	.319	.298	......	2375
6'	1' 6"	4' 2"	2' 8"	1' 6"	2' 6"	....	.424	.351	......	2750
7'	1' 6"	4' 9"	3' 1"	1' 8"	2' 6"	5' 0" lg., 2' 0" c-c.	.588	.399	3.760	3140
8'	1 6"	5' 4"	3' 7"	1' 9"	2' 6"	5' 6" lg., 2' 0" c-c.	.680	.448	4.131	3540
9'	1' 6"	5' 11"	4' 0"	1' 11"	2' 6"	5' 9" lg., 2' 0" c-c.	.826	.498	4.319	3930
10'	1' 6"	6' 9"	4' 8"	2' 1"	3' 0"	5' 9" lg., 2' 0" c-c.	1.061	.666	4.319	4320
11'	1' 6"	7' 5"	5' 2"	2' 3"	3' 0"	6' 0" lg., 2' 0" c-c.	1.197	.732	4.506	4660
12'	1' 6"	8' 0"	5' 8"	2' 4"	3' 0"	6' 0" lg., 2' 0" c-c.	1.410	.792	4.506	5000
13'	1' 6"	8' 7"	6' 1"	2' 6"	3' 0"	6' 3" lg., 1' 8" c-c.	1.619	.851	5.633	5340
14'	1' 6"	9' 2"	6' 6"	2' 8"	3' 0"	6' 6" lg., 1' 4" c-c.	1.846	.909	7.322	5680
15'	1' 6"	9' 9"	7' 0"	2' 9"	3' 0"	6' 6" lg., 1' 0" c-c.	2.108	.970	9.763	6027
16'	1' 6"	10' 4"	7' 5"	2' 11"	3' 0"	6' 9" lg., 10" c-c.	2.367	1.029	12.166	6400
17'	1' 6"	11' 0"	7' 11"	3' 1"	3' 0"	6' 9" lg., 8½" c-c.	2.662	1.097	14.313	6800
18'	1' 6"	11' 6"	8' 4"	3' 2"	3' 0"	7' 0" lg., 7" c-c.	2.955	1.140	18.024	7200
19'	1' 6"	12' 2"	8' 10"	3' 4"	3' 0"	7' 0" lg., 6" c-c.	3.284	1.218	21.028	7600
20'	1' 6"	13' 4"	9' 9"	3' 7"	4' 0"	7' 3" lg., 8" c-c.	3.654	1.731	16.334	8000
21'	1' 6"	13' 11"	10' 2"	3' 9"	4' 0"	7' 6" lg., 6½" c-c.	3.999	1.808	20.797	8400
22'	1' 6"	14' 6"	10' 8"	3' 10"	4' 0"	7' 6" lg., 5½" c-c.	4.380	1.889	24.578	8800
23'	1' 6"	15' 1"	11' 1"	4' 0"	4' 0"	7' 9" lg., 5" c-c.	4.755	1.967	27.938	9170
24'	1' 6"	15' 8"	11' 7"	4' 1"	4' 0"	7' 9" lg., 4½" c-c.	5.173	2.049	31.040	9570
25'	1' 6"	16' 3"	12' 0"	4' 3"	4' 0"	8' 0" lg., 4" c-c.	5.575	2.125	36.048	9940

TYPE 3—WALLS SUSTAINING LEVEL BANKS OF EARTH.

Clear Height H	Top Width T	Base B	B_1	B_2	Footing Depth—D	Reinforcement ¾" Round Bar	1:2½:5 Concrete per lin. ft. Cu.Yd.	1:3:6 Concrete per lin. ft. Cu.Yd.	Steel per lin. ft. Lb.	Toe Press per sq. ft. Lb.
2'	1'	1' 10"	1' 3"	7"	2' 0"	....	.079	.132	......	870
3'	1'	2' 3"	1' 6"	9"	2' 0"	....	.128	.159	......	1020
4'	1'	2' 9"	1' 10"	11"	2' 0"	....	.189	.190	......	1179
5'	1'	3' 5"	2' 3"	1' 2"	2' 6"	....	.262	.285	......	1433
6'	1'	3' 10"	2' 7"	1' 3"	2' 6"	....	.347	.320	......	1603
7'	1'	4' 3"	2' 10"	1' 5"	2' 6"	....	.435	.354	......	1773
8'	1'	4' 9"	3' 2"	1' 7"	2' 6"	....	.541	.396	......	1943
9'	1'	5' 3"	3' 6"	1' 9"	2' 6"	....	.658	.435	......	2113
10'	1'	5' 11"	3' 11"	2' 0"	3' 0"	....	.786	.578	......	2280
11'	1'	6' 4"	4' 3"	2' 1"	3' 0"	....	.927	.621	......	2430
12'	1'	6' 9"	4' 6"	2' 3"	3' 0"	6' 0" lg., 2' 0" c-c.	1.067	.663	4.506	2580
13'	1'	7' 3"	4' 10"	2' 5"	3' 0"	6' 3" lg., 2' 0" c-c.	1.230	.712	4.694	2730
14'	1'	7' 8"	5' 1"	2' 7"	3' 0"	6' 3" lg., 2' 0" c-c.	1.410	.754	4.694	2880
15'	1'	8' 2"	5' 5"	2' 9"	3' 0"	6' 6" lg., 2' 0" c-c.	1.576	.804	4.882	3100
16'	1'	8' 7"	5' 9"	2' 10"	3' 0"	6' 6" lg., 2' 0" c-c.	1.778	.847	4.882	3250
17'	1'	9' 0"	6' 0"	3' 0"	3' 0"	6' 9" lg., 2' 0" c-c.	1.968	.889	5.069	3400
18'	1'	9' 6"	6' 4"	3' 2"	3' 0"	7' 0" lg., 1' 8" c-c.	2.192	.939	6.308	3550
19'	1'	9' 11"	6' 7"	3' 4"	3' 0"	7' 0" lg., 1' 4" c-c.	2.403	.981	7.885	3700
20'	1'	10' 10"	7' 3"	3' 7"	4' 0"	7' 3" lg., 1' 10" c-c.	2.667	1.385	5.940	4272
21'	1'	11' 3"	7' 6"	3' 9"	4' 0"	7' 6" lg., 1' 6" c-c.	2.901	1.439	7.510	4412
22'	1'	11' 9"	7' 10"	3' 11"	4' 0"	7' 9" lg., 1' 2" c-c.	3.167	1.503	9.978	4552
23'	1'	12' 2"	8' 1"	4' 1"	4' 0"	7' 9" lg., 1' 0" c-c.	3.424	1.559	11.641	4692
24'	1'	12' 7"	8' 5"	4' 2"	4' 0"	8' 0" lg., 9½" c-c.	3.712	1.610	15.178	4822
25'	1'	13' 1"	8' 9"	4' 4"	4' 0"	8' 0" lg., 8½" c-c.	4.022	1.682	16.964	4970

Drainage Construction

Standards of Pennsylvania State Highway Department



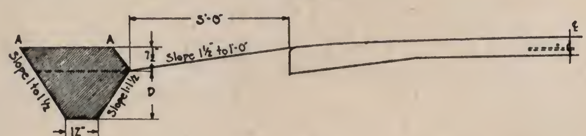
Grade	Area	Area Drained by One Ditch	Vol. of Drainage Channel Cross Hatched in Cu. Yds. per 100
0.5%	1.65 Sq. ft.	4.2 Acres	6.48 Cu. Yds.
1.0%	" "	6.0 "	" "
1.5%	" "	7.3 "	" "
2.0%	" "	8.4 "	" "
2.5%	" "	9.4 "	" "
3.0%	" "	10.8 "	" "

The Area shown cross hatched is that which is assumed to carry the drainage water as tabulated above.

The run off is calculated on the basis of one inch per acre per hour. For other run offs the drainage area may be pro rated. For example, for a run off of 2 inches per acre per hour, the standard berm on a 2% grade would handle the water from 4.45 acres.

Assumptions :- Velocity $= 57\sqrt{rs}$
$r = 0.4$
$n = 0.2$

Standard Drainage Ditch for Pervious Soils Such as Sand or Gravel.



Grade	D = 18"			D = 24"			D = 30"			D = 36"		
	Area	Acres	Vol. 100'	Area	Acres	Vol. 100'	Area	Acres	Vol. 100'	Area	Acres	Vol. 100'
0.5%	4.87 Sq.'	11.0	18.0 C.Y.	6.88 Sq.'	22.0	25.5 C.Y.	9.35 Sq.'	33.0	34.6 C.Y.	12.1 Sq.'	50.0	44.8 C.Yd.
1.0%	"	16.0		"	29.0	"	"	46.0	"	"	70.0	"
1.5%	"	19.0		"	36.0	"	"	57.0	"	"	86.0	"
2.0%	"	22.0	"	"	41.0	"	"	65.0	"	"	99.0	"
2.5%	"	25.0	"	"	46.0	"	"	73.0	"	"	111.0	"
3.0%	"	27.0		"	50.0	"	"	80.0	"	"	121.0	"

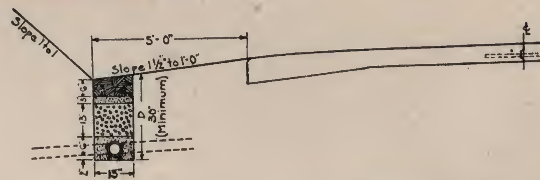
Assumptions	D = 18"	D = 24"	D = 30"	D = 36"
	$n = .02$ $r = .65$ $V = 65\sqrt{rs}$ Wetted Perim. = 4.6	$n = .02$ $r = .80$ $V = 69\sqrt{rs}$ Wetted Perim. = 5.8	$n = .02$ $r = .93$ $V = 71\sqrt{rs}$ Wetted Perim. = 7.0	$n = .02$ $r = 1.1$ $V = 74\sqrt{rs}$ Wetted Perim. = 8.2

The major use of this section will be on side hills where the cutting is light. This section may be used on grades up to 3%.

The columns giving the volumes per 100 lin. ft of ditch are for the section shown by light cross hatching. For extra cutting on side hills the prism above the line A-A must be added in working up comparative schemes.

The run off is calculated on the basis of one inch per acre per hour. For other run offs the drainage area may be pro rated. For example, for a run off of 2 inches per acre per hour, the standard 18" ditch on a 2% grade would handle the water from 11.0 acres.

Standard Drainage Ditch to Be Used Where the Soil Is Impervious. Ditch to Be Designed of Sufficient Area to Carry Surface Water.



Grade	Area	Area Drained
0.5%	.087 Sq.ft.	0.10 Acres
1.0%	" "	0.14 "
1.5%	"	0.17 "
2.0%	" "	0.20 "
2.5%	"	0.22 "
3.0%	" "	0.24 "

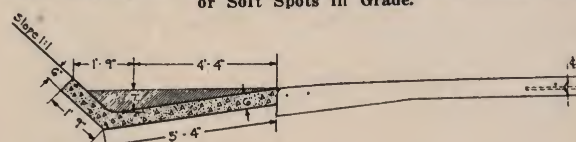
Quanities for 100 Lin. ft. of drain.				
Depth	L. of Pipe	Excav.	Stone	Wrapping
D	—	—	—	—
2.5	100'	11.2 Cu. Yd	8.1 Cu. Yd	22.0 Sq. Ft.
3.0	"	13.5 " "	" "	" "
3.5	"	17.2 " "	" "	" "
4.0	"	20.7 " "	" "	" "

The drainage area given in this table is Theoretical and is based on the assumptions that the pipe carries all of the water. Practically, the greater part of the run off will be carried by the berm shown. The drain pipe acting only as an interceptor for sub surface drainage.

The run off is calculated on the basis of one inch per acre per hour. For other run offs the drainage area may be pro rated. For example, for a run off of 2 inches per acre per hour, the standard tile drain on a 2% grade would handle the water from 0.1 Acres.

Assumptions: Velocity $= 56\sqrt{rs}$
$n = .014$
$r = .08$
Diam. of Pipe 4"

Standard Tile Drain for Use in Well Defined Stratified Pervious Water Bearing Soil on Impervious Layers and in Draining Springy or Soft Spots in Grade.



Grade	Area	Velocity V	Drainage Area	Quantities: Excav. for 100'	Quantities: Conc. for 100'
1.0%	1.73 Sq.ft	5.7	10.0 Acres	12.9 Cu. Yds.	78.5 Sq. Yds.
2.0%		8.1	14.0 "	" "	" "
3.0%	" "	10.0	17.0 "	" "	" "
4.0%	" "	11.4	20.0	" "	" "
5.0%	" "	12.7	22.0 "	" "	" "
6.0%	"	14.0	24.0 "	" "	" "
7.0%	" "	15.1	26.0 "	" "	" "
8.0%	" "	16.2	28.0 "	" "	" "
9.0%	" "	17.1	30.0 "	" "	" "
10.0%	" "	18.1	31.0 "	" "	" "

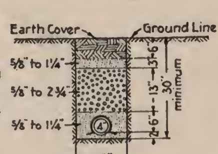
The excavation in column five in Cu. Yds. per 100 lin. ft. is the amount over that of Standard Berm shown in Type I

The run off is calculated on the basis of one inch per acre per hour. For other run offs the drainage area may be pro rated. For example for a run off of 2 inch per acre per hour, the standard gutter on a 2% grade would handle the water from 7.00 Acres.

Assumptions $n = .013$
$r = .36$
$v = 95\sqrt{rs}$

Standard Section Showing Plain Cement Concrete Gutter for Grades Up to 10 Per Cent.

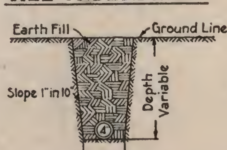
Pipe Joint to be covered with two (2) ply tar paper not less than six (6) inches in width, 24" long. Variable depth of excavation in excess of thirty (30) inches below the surface of the ground at point where drain is placed to be paid for as Excavation



Required per lin ft.
.0501 cu. yds. of 5/8" to 2¾" Stone.
.0374 cu. yds of 5/8" to 1¼" Stone
One (1) lin ft of 4" Vit Clay or Cem. Conc. Pipe

TILE UNDERDRAIN.

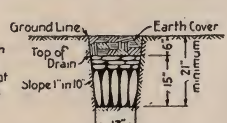
Outlet end to be protected with end wall.
Joints to be cemented with 1 2 Mortar



Required per lin ft.
One (1) lin ft of 4" Vit. Clay or Cem. Conc. Pipe

TILE OUTLETS FOR UNDERDRAINS.

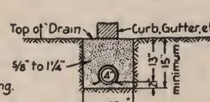
Variable depth of excavation in excess of twenty-one (21) inches below the surface of the ground at point where drain is placed to be paid for as "Excavation"



Required
.052 cu yds. of Stone per lineal foot solid

STONE UNDERDRAIN.

Pipe Joint to be covered with two (2) ply tar paper not less than six (6) inches in width, 24" long.



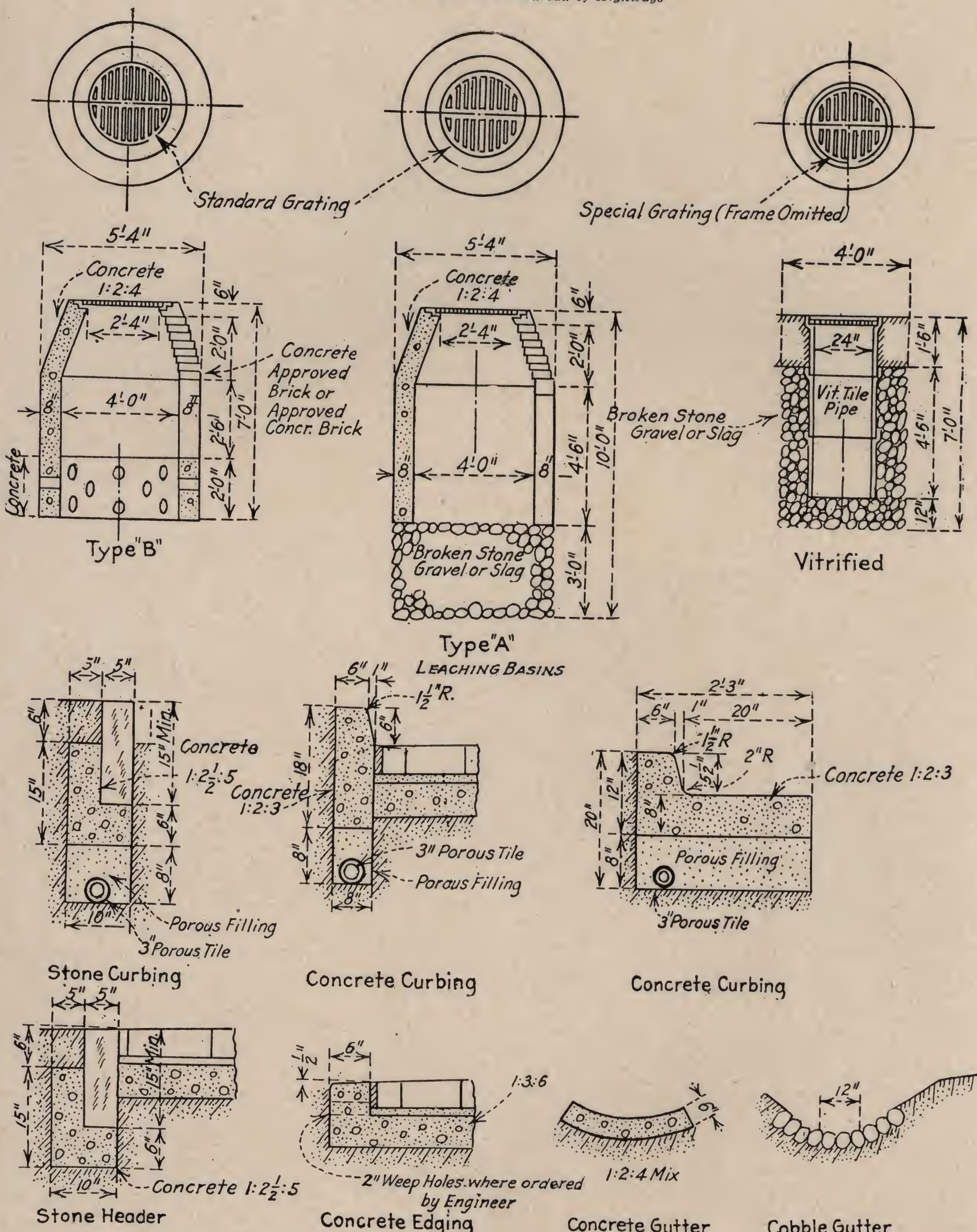
Required per lin ft.
.0528 cu. yds of 5/8" to 1¼" Stone
One (1) lin ft. of 4" Vit Clay or Cem Conc. Pipe

TILE FOUNDATION UNDERDRAIN

Standard Underdrains of Pennsylvania State Highway Department

Standard Details for Pavements

Standard New York State Bureau of Highways



METHOD OF FIGURING STREET INTERSECTION GRADES.—Street intersection grades often keep the municipal engineer burning the midnight oil. No fixed rule for figuring grades will apply everywhere. A method that has been successfully used at Everett, Wash., where steep slopes are frequent, was described as follows in *Roads and Streets* by Maj. A. B. Cutter, City Engineer:

1. Draw a sketch of the intersection

2. Connect the curb radius points G (see Fig. 1) by straight lines. Then the elevation of the pavement at A, C or E is the mean of the corresponding gutter grades at D plus the total crown of the pavement. The elevation at B should be 1 or 2 in. above a straight grade between A and E or C and C.

3. Locate points on the respective center lines either by quartering the curb arc, as on ABC, or by measuring given distances on the center line, as on CBE. The latter method is more easily reproduced in the field before the curb returns have been set.

4. Connect these points on the center line with the curb radius points G by a straight line and measure the unknown distances.

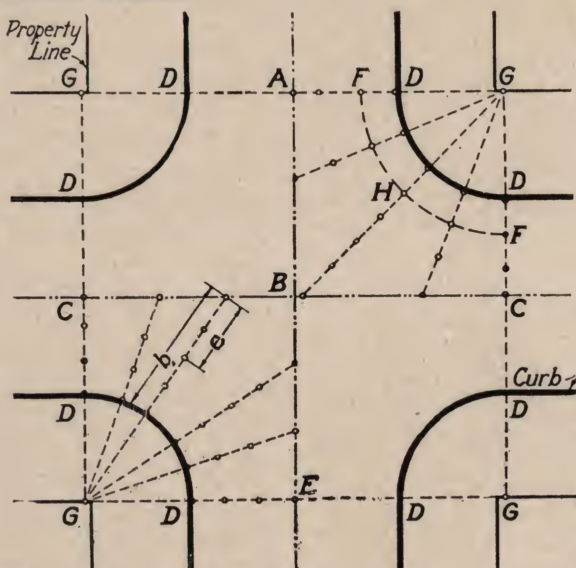


Fig. 1

5. Figure straight grades on the center lines AB, BC and BE, and on the gutter lines around the arc of the curb DD.

6. Elevations between the points on the gutter line and those on the center line are figured by the parabolic curve equation

$$\left(\frac{a}{b^2}\right) e^2 = y$$

when

a = difference in elevation, b = distance } Between points on the center line and corresponding points at the gutter.

e = distance between the point on center line and the point whose elevation is desired.

y = fall from point on center line to point in question.

Results obtained by this method may need to be adjusted to fit special conditions.

When the slope across the intersection is rather steep, one gutter line may be above corresponding points on the center line. If a combination curb and gutter is used, with an apron sloping toward the curb, the pavement and apron will meet in a ridge which will not look or wear well. This may be avoided by figuring elevations on an arc, as FF, near the apron line, at about the elevation of the apron edge, so that no ridge will be formed. Then connect points on this arc with corresponding points on the center line by a straight grade.

If the high point of the crown, between intersections, has been shifted from the center line to compensate for gutters of unequal elevation, the elevation of A, C or E cannot be found as described in paragraph 2. It can be found, however, from the grade between intersections. Then the high point in the crown must be combined smoothly with the intersection grades. If F is the high point in the crown, the elevation of H can be figured as in paragraph 6 and a uniform grade made from H to F.

Elevations between points on FF and the center line are then figured as described in paragraph 6, or as a straight grade, depending on whether points on FF are below or above corresponding points on the center line.

When the grade between centers of intersections is less than 3 per cent it may be carried through the block without a break, but when it is more it is best to flatten

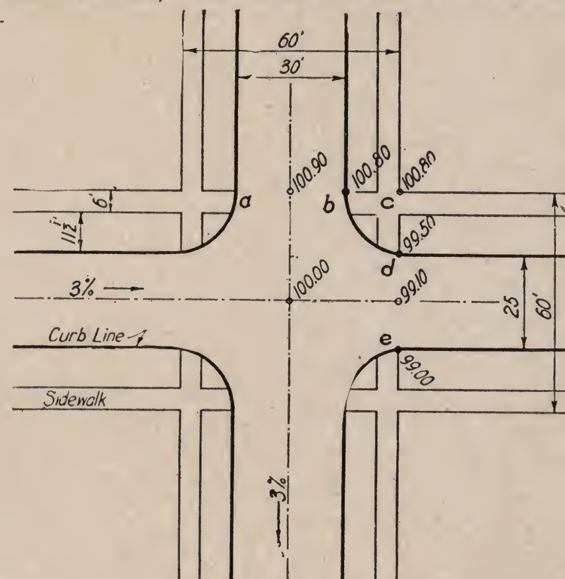


Fig. 2

the grade through the intersection to 3 per cent, make a break at the property line (extended) and increase the grade through the block accordingly.

If the grade on center lines through intersections exceeds 3 per cent, it is nearly impossible to fit the sidewalk elevation to the curb elevation without excessive slopes on the cross walks.

For example, Fig. 2 shows an intersection with center line grades of 3 per cent. Curbs at A and B and at D and E have been given all the difference in elevation possible without making the pavement slope too steeply toward the lower curb.

Sidewalks should not be lower than the curb, so the elevation of the walk at C has been made the same as the curb at B, making a slope from C to D of 1.3 ft. in 11.5 ft., or an 11.3 per cent grade, which is dangerously steep. A wider pavement would increase this steep slope, so, even for the moderately difficult intersection shown, the center line grades cannot exceed 3 per cent.

When all elevations have been put upon the sketch of the intersection they should be carefully examined for inconsistencies.

Effect of Street Widening on Value of Abutting and Adjoining Property

How much does the widening of a street or the widening of city pavement affect the value of abutting and adjoining property? Well-authenticated information on this question grows more important as increasing numbers of cities resort to street-widening to meet a multiplying motor transportation.

Results of Questionnaire.—To get such information, a survey among both municipal and private engineers was conducted. Returns showed that (1) in many cases records are not available over a sufficient period of years prior to the widening to give an accurate measure of its influence on property values; (2) that in other cases the necessary time has not elapsed since the widening to show what the full effects are; (3) that in many other instances factors, at present inseparable from the widening itself, have operated with it to produce a given result. These limitations, while preventing any graphical or tabular interpretation of the results as a whole, do not impair the worth of certain data that was obtainable, or present comparisons confined to a single city where differences in methods of levying taxes are presumably known to the man giving the figures.

Different Types of Development.—In a general way, the survey uncovered several distinctly different types of development that have been concurrent with or have followed closely major street-widenings. Some of these types are:

1. A stimulation of either business or residential growth on subdivided properties. This was noticeable where the widening made more or less of a main thoroughfare out of what had been simply a street. Stuyvesant Ave., Union County, New Jersey, is in part an illustration.
2. A change in the main use of the property from residential to business. Parts of Florence Ave., Los Angeles, are examples.
3. An increase in the desirability of business property, as such. Michigan Ave., Chicago, is an example.
4. An increase in the desirability of residence property as such. On this property apartment houses and apartment hotels replace to a large extent the single residence.
5. A radical change in the type of business conducted along a street. For an example, South Water Street, along the river in Chicago, long the province of wholesale produce dealers, has by widening and double decking become Wacker Drive, lined by skyscrapers.

The survey also brought to light numerous examples of more specific information. Samples are presented here in three groups: (A) Comparisons between comparable widened and unwidened streets where the depths of lots on the two streets compared do not differ by more than 10 ft.; (B) Similar comparisons where these depths differ by from 10 ft. to 50 ft.; (C) Opinions expressed where the engineer found his data insufficient or where he felt that any actual comparison that he might make would be misleading.

Streets Fairly Comparable.—Streets in the following cities were compared in pairs and were judged fairly comparable before widening took place. The figures quoted are average tax values per front foot on lots differing no more than 10 ft. in depth.

New Haven, Conn.:

Property on Chapel Street, widened in 1910, was taxed at $400 per front foot in 1919 and $625 in 1927, an increase of 56 per cent. Property on George Street, an unwidened street given as comparable, was taxed $400 per front foot in 1919 and $425 in 1927, an increase of 6 per cent.

Milwaukee, Wis.:

Property on Oklahoma Avenue, widened from 66 ft. to 100 ft. on proceedings that began in 1915, was taxed $11.49 per front foot in 1919 and $42.05 in 1927, an increase of about 265 per cent. Manitoba Street, an unwidened street called comparable, showed an increase of 35 per cent in the same period.

St. Louis, Mo.:

Property on Seventh Street, widened from 60 ft. to 80 ft. in 1919, was taxed $85 per front foot in 1919 and $120 in 1927, an increase of about 41 per cent. Sixth Street, an unwidened comparable street, showed an increase of from $75 to $95 per front foot, or 27 per cent, in the same period.

Cleveland, O.:

Property on Superior Ave., widened from 50 ft. to 76 ft. in 1920, was taxed an average of $530 per front foot in 1920 and $1,279 in 1927, an increase of 141 per cent. Property on St. Clair Ave., unwidened street given as comparable, was taxed at $235 per front foot in 1920 and $328 in 1927, an increase of 40 per cent.

Streets Fairly Comparable Before Widening Took Place.—The following pairs of streets were judged fairly comparable before widening took place. The figures quoted are average tax values per front foot on lots differing from 10 ft. to 50 ft. in depth.

Chicago, Ill.:

Property on Wacker Drive (formerly South Water Street), widened and doubledecked in 1926, was assessed at $1,000 per front foot in 1919 and at $3,500 per front foot in 1927, an increase of 250 per cent. Market Street, an awkward street, also bordering the downtown district, was assessed at $1,300 per front foot in 1919 and at $1,500 in 1927, an increase of 15 per cent.

Charleston, W. Va.:

Property on Summers Street, widened from 45 ft. to 76 ft. (paving widened from 30 ft. to 46 ft.), was rated at $325 per front foot in 1919 and at $1,000 per front foot in 1927, an increase of about 207 per cent. Values on Capital Street, an unwidened street listed as fairly comparable, went from $1,500 to $2,000 per front foot in the same period or an increase of 33⅓ per cent.

Akron, O.:

Property on North Main Street, widened in 1922 from 50 ft. to 90 ft., was valued for tax purposes at $40 per front foot in 1919, at $26 in 1923 and at $60 in 1927, a total net increase of 50 per cent. Property on East Exchange Street, a comparable unwidened thoroughfare, was valued at $175 per front foot in 1919, at $120 in 1923 and at $124 in 1927, total net decrease of about 30 per cent. The fall in tax values in 1923, according to the Highway Engineer of Akron, was due to an arbitrary reduction by the county auditor, and the subsequent rise to re-appraisal.

Baltimore:

In this case, depth of lots on the streets differed by more than 50 ft. after widening.

Property on Hillen Road, widened from 33 ft. to 120 ft. in 1923, was valued at $535 per front foot in 1919 and at $1,895 in 1927, an increase of about 254 per cent.

Property on Falls Road, comparable unwidened street, went from $2,150 to $3,610 in the same eight years, the increase being about 68 per cent.

It will be noted in these samples, that in some cases the property values on widened streets exceed those on unwidened ones. In other cases the reverse is true, but in all cases the increase in tax value is greater on the widened than on the unwidened street.

Opinions of Various Officials.—The following are some of the opinions given by various officials. They are presented without any added comment.

District of Columbia:

"In the estimation of the Board of Assessors, all widening of streets and roadways has had a decided influence in increasing the values of abutting properties. The office could point to some cases where property values were more or less on a downward course and that such a tendency has been arrested by the widening and improving of roadways."—Wm. P. Richards, Assessor.

New Britain, Conn.:

"The only thoroughfare widened on which any data may be available is Chestnut Street widening, just completed. No data as to increase or probable increase available. It is safe to assume the value of this street—centrally located—is due to increase. It is very probable that the widening will hurry this increase in value."—Thomas Linder, Chairman of Board of Assessors.

Flint, Mich.:

"We have had a number of cases where pavements were widened to accommodate business development along certain streets or portions of streets, on petition of the property owners. In these instances, the increased value of the property is apparent from the rapid development of the district."—Harry C. McClure, City Engineer.

Lakewood, O.:

"We have a small street-widening program in 1928, but no figures are available.

"On business streets unquestioned values are made because of increased accessibility. Our main thoroughfare, 66 ft. wide (paved 42 ft.), is too narrow to do business on. An 86-foot width with 56-foot paving would probably double the value of property in the business districts. Parking for shopping is the big problem in cities up to 100,000. (We now have a population of 65,000.)

"In business districts or projected business districts and along main traveled routes, street-widening for present and future traffic demands should show increased property values in excess of the cost of the improvement."—E. A. Fisher.

Winston-Salem, N. C.:

"We have several projects involving the widening of existing streets in the downtown districts which we propose to put through this year on petition of property owners. On one of these streets, the property owners have agreed to bear the entire cost of the project. There are four projects upon which property owners have agreed to pay 75 per cent on the cost of the work. In cases where the Board of Aldermen have instigated the widening of existing streets, the property owners pay only 50 per cent of the cost.

"As a general proposition, I would say without hesitancy that the widening of the street greatly increases the value of abutting and adjoining property."—Harry L. Shaner, Commissioner of Public Works.

Attention might also be called here to analysis of street widening in Los Angeles by John C. Shaw, City Engineer, Board of Public Works, Los Angeles, which appears in this issue of Roads and Streets.

It is only by the collection in the future of data as exact as is obtainable that the full influence of street widening on property values can be obtained. In the light of the above and similar information, and in the absence of any contrary facts, it seems safe to generalize to the extent of saying that street widening or pavement widening not only makes traffic handling more efficient but that it decidedly profits the owners of property along and near the street improved; that furthermore, the increase in tax income following widening reimburses the city to a considerable extent for its share of the expense.

Miscellaneous Tables

SQUARE YARDS OF SURFACE AND CUBIC YARDS OF VOLUME PER 100 FT. AND PER MILE

Width in Feet	Number of Sq. Yds.		Number of Cubic Yards for Different Depths, Lengths and Widths																							
			1 In. Deep		2 In. Deep		3 In. Deep		4 In. Deep		5 In. Deep		6 In. Deep		7 In. Deep		8 In. Deep		9 In. Deep		10 In. Deep		11 In. Deep		12 In. Deep	
	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.	100 ft.	1 mile.
1	11.11	587	.31	16	.62	33	.93	49	1.24	65	1.54	81	1.85	98	2.16	114	2.47	130	2.78	147	3.09	163	3.40	179	3.70	196
2	22.22	1,174	.62	32	1.25	66	1.85	98	2.47	130	3.09	163	3.70	196	4.32	228	4.94	260	5.56	293	6.17	326	6.79	359	7.41	381
3	33.33	1,760	.93	49	1.86	98	2.78	147	3.70	195	4.63	244	5.56	293	6.48	342	7.43	391	8.33	440	9.26	489	10.19	538	11.04	587
8	88.89	4,693	2.47	130	5.00	261	7.41	391	9.88	521	12.35	652	14.82	782	17.28	913	19.75	1,043	22.67	1,173	24.69	1,304	27.16	1,434	26.63	1,564
10	111.11	5,867	3.09	163	6.25	326	9.26	489	12.35	652	15.43	815	18.52	978	21.61	1,141	24.69	1,304	27.78	1,467	30.86	1,630	33.95	1,793	37.04	1,956
12	133.33	7,040	3.24	196	7.41	391	11.11	587	14.27	782	18.52	978	22.22	1,173	25.93	1,369	29.63	1,564	33.33	1,760	37.04	1,956	40.25	2,151	44.45	2,347
14	155.56	8,213	4.32	228	8.77	456	12.96	684	17.28	913	21.61	1,141	25.93	1,369	30.25	1,597	34.57	1,825	38.89	2,053	43.21	2,282	47.49	2,510	51.85	2.738
15	166.67	8,800	4.63	244	9.26	489	13.89	733	18.17	978	23.15	1,222	27.78	1,467	32.41	1,711	37.04	1,956	41.67	2,196	46.30	2,444	50.31	2,689	55.56	2,933
16	177.78	9,387	5.00	261	9.88	521	14.82	782	19.75	1,043	24.69	1,304	29.63	1,564	35.00	1,827	39.51	2,086	44.45	2,347	49.63	2,608	54.32	2,868	59.26	3,130
18	200.00	10,560	5.56	293	11.11	587	16.67	880	22.22	1,173	27.78	1,467	33.33	1,760	38.89	2,053	44.45	2,347	50.00	2,640	55.56	2,933	61.11	3,227	66.67	3,520
20	222.22	11,734	6.25	326	12.35	652	18.52	978	24.69	1,304	30.86	1,630	37.04	1,956	43.21	2,282	49.38	2,609	55.56	2,933	61.73	3,256	67.90	3,585	74.07	3,911
22	244.44	12,907	6.79	359	13.58	717	20.12	1,076	27.16	1,434	33.95	1,793	40.74	2,151	47.53	2,510	54.33	2.868	61.11	3,227	67.90	3,585	74.69	3,943	81.48	4,302
24	266.67	14,080	7.14	391	14.27	782	22.22	1,173	29.21	1,564	37.09	1,956	44.45	2,347	51.85	2,738	59.26	3,130	66.67	3,520	74.07	3,911	81.16	4,302	88.89	4,693
26	288.89	15,253	8.03	423	16.05	847	24.07	1,271	32.10	1,695	40.12	2,119	48.15	2,542	56.17	2,966	64.20	3,448	72.22	3,813	80.25	4,237	88.27	4,661	96.30	5,085
28	311.11	16,426	8.64	456	17.28	913	25.93	1,369	34.57	1,825	43.21	2,282	51.85	2,733	60.49	3,194	69.14	3,650	77.78	4,107	86.42	4,563	95.62	5,020	104.00	5,476
30	333.33	17,600	9.14	489	18.17	978	27.78	1,467	37.04	1,956	46.30	2,444	55.56	2,933	64.82	3,422	74.07	3,911	83.33	4,400	92.20	4,889	102.00	5,378	111.00	5,867
35	388.89	20,533	10.80	570	21.61	1,141	32.44	1,711	43.21	2,282	54.00	2,852	65.00	3.422	76.00	3,993	86.00	4,563	97.06	5,133	108.00	5,704	119.00	6,274	130.00	6,844
40	444.44	23,468	12.35	652	24.69	1,304	37.04	1,956	49.38	2,347	61.73	3,256	74.00	3,911	86.00	4,563	99.00	5,215	111.00	5,867	123.00	6,519	136.00	7,170	148.00	7,822

LINEAL INCLINED DISTANCES ON VARIOUS GRADES (EXPRESSED IN PER CENT AND DEGREES) FOR 1000 FT. HORIZONTAL

Grade %.	Grade Degrees.	Inclined Distance.	Grade %.	Grade Degrees.	Inclined Distance.
0.5	0° 17′	1,000.01	5.3	3° 2′	1,001.40
0.8	0° 28′	1,000.03	5.4	3° 5′	1,001.46
1.0	0° 35′	1,000.05	5.5	3° 9′	1,001.51
1.1	0° 38′	1,000.06	5.6	3° 12′	1,001.57
1.2	0° 42′	1,000.07	5.7	3° 16′	1,001.62
1.3	0° 45′	1,000.08	5.8	3° 19′	1,001.68
1.4	0° 48′	1,000.10	5.9	3° 23′	1,001.74
1.5	0° 51′	1,000.11	6.0	3° 26′	1,001.80
1.6	0° 55′	1,000.13	6.1	3° 29′	1,001.86
1.7	0° 58′	1,000.15	6.2	3° 33′	1,001.92
1.8	1° 2′	1,000.16	6.3	3° 36′	1,001.98
1.9	1° 5′	1,000.18	6.4	3° 40′	1,002.05
2.0	1° 9′	1,000.20	6.5	3° 43′	1,002.11
2.1	1° 12′	1,000 22	6.6	3° 46′	1,002.18
2.2	1° 16′	1,000.24	6.7	3° 50′	1,002.24
2.3	1° 19′	1,000.26	6.8	3° 53′	1,002.30
2.4	1° 22′	1,000.29	6.9	3° 57′	1,002.38
2.5	1° 26′	1,000.31	7.0	4° 00′	1,002.45
2.6	1° 29′	1,000.34	7.1	4° 4′	1,002.52
2.7	1° 33′	1,000.36	7.2	4° 7′	1,002.59
2.8	1° 36′	1,000.39	7.3	4° 11′	1,002.66
2.9	1° 40′	1,000.42	7.4	4° 14′	1,002.73
3.0	1° 43′	1,000.45	7.5	4° 17′	1,002.81
3.1	1° 47′	1,000.48	7.6	4° 21′	1,002.89
3.2	1° 50′	1,000,51	7.7	4° 24′	1,002.96
3.3	1° 53′	1,000.54	7.8	4° 28′	1,003.04
3.4	1° 57′	1,000.58	7.9	4° 31′	1,003.12
3.5	2° 00′	1,000.61	8.0	4° 34′	1,003.19
3.6	2° 4′	1,000.65	8.5	4° 52′	1,003.61
3.7	2° 7′	1,000.68	8.7	5° 00′	1,003.82
3.8	2° 11′	1,000.72	9.0	5° 9′	1,004.04
3.9	2° 14′	1,000.76	9.5	5° 26′	1,004.50
4.0	2° 17′	1,000.80	10.0	5° 43′	1,004.99
4.1	2° 21′	1,000.84	10.5	6° 00′	1,005.50
4.2	2° 24′	1,000.88	11.0	6° 17′	1,006.03
4.3	2° 28′	1,000.92	11.5	6° 34′	1,006.59
4.4	2° 31′	1,000.96	12.0	6° 51′	1,007.17
4.5	2° 35′	1,001.01	12.3	7° 00′	1,007.56
4.6	2° 38′	1,001.06	12.5	7° 8′	1,007.78
4.7	2° 41′	1,001.10	13.0	7° 24′	1,008.41
4.8	2° 45′	1,001.15	13.5	7° 41′	1,009.07
4.9	2° 48′	1,001.20	14.0	7° 58′	1,009.75
5.0	2° 52′	1,001.25	14.1	8° 00′	1,009.81
5.1	2° 55′	1,001.30	14.5	8° 15′	1,010.46
5.2	2° 59′	1.001.35	15.0	8° 32′	1,011.19

APPROXIMATE WEIGHTS IN POUNDS PER CUBIC FOOT AND PER CUBIC YARD AND SPECIFIC GRAVITY OF VARIOUS MATERIALS

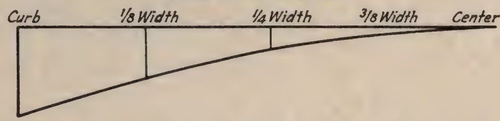
Substance.	Lbs. Per Cu. Ft.			Lbs. Per Cu. Yd.			Sp. Gr.
	Min.	Max.	Ave.	Min.	Max.	Ave.	
Limestone (Solid)	156	175	168	4,220	4,730	4,540	2.5-2.8
Limestone—Crusher Run	93	107	96	2,500	2,900	2,600	....
Limestone—Crushed (Screened)	89	104	93	2,400	2,800	2,500	....
Marble (Solid)	156	175	168	4,220	4,730	4,540	2.5-2.8
Granite (Solid)	159	187	172	4,300	5,050	4,650	2.55-3.0
Granite—Crushed (Screened)	93	107	96	2,500	2,900	2,600	....
Slag—Crusher Run	70	96	78	1,900	2,600	2,100	....
Slag (Screened)	67	93	74	1,800	2,500	2,000	....
Sandstone (Solid)	131	162	149	3,540	4,380	4,030	2.1-2.6
Sandstone—Broken	76	93	85	2,050	2,500	2,300	....
Sand—Dry	93	115	100	2,500	3,100	2,700	....
Gravel—Unscreened Bank	96	119	111	2,600	3,200	3,000	....
Gravel—Washed, Graded	93	115	104	2,500	3,100	2,800	....
Concrete (Cement)—Plain: Stone	135	150	142	3,650	4,050	3,825	2.2-2.4
Concrete (Cement)—Plain: Slag	125	136	130	3,375	3,675	3,500	2.0-2.2
Concrete (Cement)—Reinforced: Stone	145	155	150	3,900	4,200	4,050	2.3-2.5
Concrete (Cement)—Reinforced: Slag	135	145	140	3,650	3,900	3,800	2.2-2.3
Steel	486	492	490	....	....	....	7.8-7.9
Cast Iron	430	461	450	....	....	....	6.9-7.4
Wrought Iron	474	492	485	....	....	....	7.6-7.9
Asphaltum	62	106	87	....	....	....	1.0-1.7
Tar	62	75	68	....	....	....	1.0-1.2
Brick Pavement: Cement Grout Filler	......	......	142	....	....	....	....
Brick Pavement: Bituminous Filler	......	......	139	....	....	....	....
Brick Pavement: Mastic Filler	......	......	144	....	....	....	....
Granite Pavement—Grout Filler	......	......	108	....	....	....	....
Sheet Asphalt Pavement	......	......	135	....	....	....	....
Creosoted W. B. Pavement	......	......	57	....	....	....	....

Highway Engineering Short Cuts

Crown, Superelevation and Widths of Surfacing on Curves

The following tables are used by the State Highway Department of Maryland:

Distance below center for each 1/8 width point for any crown from 1 in. to 8 in.



Crown	1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.
1/8 width	1/2	1 1/8	1 5/8	2 1/4	2 3/4	3 3/8	3 7/8	4 1/2
1/4 width	1/4	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2
3/8 width	1/16	1/8	1/8	1/4	1/4	3/8	3/8	1/2
Center	0	0	0	0	0	0	0	0

Crown Elevation per foot of width for various surfacing

Kind of Surfacing	Rise per ft. of width
Vitrified block	3/8
Wood block	3/8
Bituminous surface	3/8
Concrete surface	3/8 to 3/4
Stone block	1/2 to 3/4
Waterbound macadam	1/2 to 3/4

Additional Widths of Surfacing on Curves of Different Radius

Radius of center line ft.	Additional width	Rise per ft. of width for conc. surf.	Radius of center line ft.	Additional width	Rise per ft. of width for conc. surf.
30	8.0	3/4	260	3.0	3/4
40	7.0	3/4	280	3.0	3/4
60	6.0	3/4	300	3.0	3/4
80	5.0	3/4	400	3.0	3/4
100	4.5	3/4	500	3.0	3/4
120	4.0	3/4	600	3.0	1/2
140	4.0	3/4	700	3.0	1/2
160	3.5	3/4	800	3.0	1/2
180	3.5	3/4	900	3.0	1/2
200	3.0	3/4	1000	3.0	3/8
220	3.0	3/4	1100	3.0	3/8
240	3.0	3/4	1200	3.0	3/8

Right of Way Calculations

The following methods are taken from instructions prepared by the Highway Department of South Dakota for the guidance of its engineers.

Method of Calculating Station of Intersection of a Given Curve and a Land Line.—Given: Radius of curve, degree of curve, tangent length to intersecting land line and bearing of tangent. This is for true north and south land lines. For other lines the proper modifications can easily be introduced.

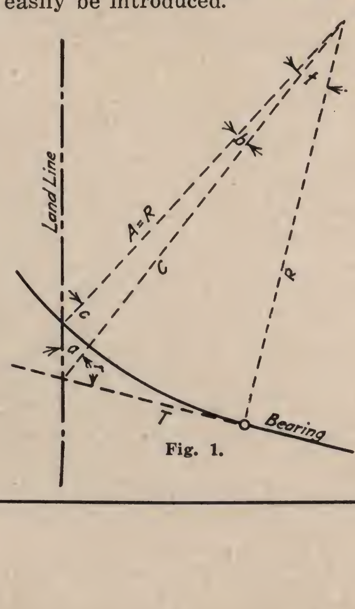


Fig. 1.

$$C=\sqrt{R^2+T^2}$$

$$\text{Sin } t=\frac{T}{C}$$

$$r=90-t$$

$a=180-(\text{Bearing}+r)$ or
$r-\text{Bearing}$ as the case may be

$$\text{Sin } c=\frac{\text{Sin } a}{R}\times C$$

(Angle thus calculated may have to be deducted from 180°)

$$b=180-(c+a)$$

$$\text{Length of Curve}=\frac{100\ (b+t)}{\text{Degree of Curve}}$$

Example:

$D=10°$; $R=573.0$; $T=300.0$
Bearing N65° 00′W

$$C=\sqrt{573.0^2+300.0^2}=\sqrt{328329+90000}$$

$$=\sqrt{418329}=646.8$$

$$\text{Sin } t=\frac{300}{646.8}=.46382;\ t=27°\ 38'$$

$$r=90°\ 00'-27°\ 38'=62°\ 22'$$

$$a=180°-(65°\ 00'+62°\ 22')=52°\ 38'$$

$$\text{Sin } c=\frac{.79477\times 646.8}{573.0}=.89713$$

Angle=63° 47′ to be deducted from 180° $c=180°\ 00'-63°\ 47'=116°\ 13'$

$$b=180°-(116°\ 13'+52°\ 38')=11°\ 09'$$

$$\text{Length of Curve}=100\frac{(11°\ 09'+27°\ 38')}{10}$$

$$=L=387.6'$$

To find (see Fig. 1): Angles a, r, c, b and t, side c, and length of curve over b+t.

To Find Length of Curve.—The method of determining station of intersection of 33 ft. right of way line and a curve having a section line as a tangent is as follows:

Given: Degree of curve and radius. To find (see Fig. 2): x, y, a, length of curve.

$$x=\sqrt{r^2-(r-33)^2}$$

$$y=\sqrt{33^2+x^2}$$

$$\text{Sin } a=\frac{33}{y}$$

$$\text{Length of Curve }\frac{100a}{\frac{1}{2}D}$$

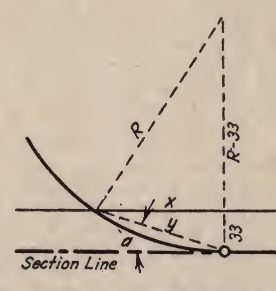


Fig. 2.

Example:

$D=8°$; $R=716.2$; $R-33=683.2$

$$x=\sqrt{512942-466762}=\sqrt{46180}$$
$$=214.9$$

$$y=\sqrt{33^2+214.9^2}=\sqrt{47269}$$
$$=217.4$$

$$\text{Sin } a=\frac{33}{217.4}=0.151794;\ a=8°\ 44'$$

$$\text{Length of Curve}=\frac{873.3}{4}=218.3$$

Estimating Data for Highway Bridges

METHOD OF FINDING UNIT ESTIMATING PRICES FOR STRUCTURAL AND REINFORCING STEEL.—Data derived from actual cost records are used by the Bridge Department of the Illinois Division of Highways in preparing its estimate for highway bridges. We are indebted to G. F. Burch, Bridge Engineer of the Division for the following particulars:

Trusses.—Assume 100 ft. span. Weight 86,620 lb. Material: Either mill or warehouse price or half of each, depending on supply and demand. Use current price for beams, channels, angles and plates. Freight: For mill price use C. L. price from Pittsburgh to Springfield plus C. L. price from Chicago to Springfield. For warehouse price use twice C. L. price from Chicago to Springfield. Shop work: Base of $0.70 per 100 lb. with 40 cent labor. This includes shop coat of paint at $1.50 per gallon. Use current prices of shop labor and paint. Falsework and erection: Base of $11.00 per ton for bolting, placing and falsework with 40 cent labor. For riveting use 1,750 rivets at $0.08 each with 40 cent labor. Use current prices for labor. Paint: Use sheet "Painting New Steel Bridges." Neglect freight. Haul: Assume 3,000 lb. load and 4 trips per day. Use current price of teams. Profit: Use 25 per cent.

Plate Girders for Overheads.—Same as "Trusses" except use half of erection cost and five-sixteenths of shop work cost. When gunite is used omit field paint.

I-Beams.—Material: Either mill or warehouse or half of each. Use current price of I-beams. Freight: For mill price use C. L. price from Pittsburgh to Springfield plus L. C. L. price from Chicago to Springfield. For warehouse price use C. L. price Chicago to Springfield plus L. C. L. price Chicago to Springfield. Shop Work Base of $0.35 per 100 lb. with 40 cent labor. Use current price of labor. Falsework and erection: Same assumptions as shop work. Paint: Use sheet "Painting New Steel Bridges." Neglect freight. Haul: Assume 3,000 lb. load and 4 trips per day. Use current price of teams. Profit: Use 25 per cent.

Reinforcing Steel.—Material: Use current price of ½ in. square bars at either mill or warehouse price or half of each. Freight: For mill price use L. C. L. price from Pittsburgh to Springfield. For warehouse price use L. C. L. price from Chicago to Springfield. Bending and placing: Use 1 man hour per 100 lb. at current labor price. Haul: 3,000 lb. load and 4 trips per day. Use current price of labor. Profit: Use 35 per cent.

Cleaning and Painting Old Steel Bridges

Amount of paint required per ton:

1st coat	½ gal.
2nd coat	½ gal.
3rd coat	½ gal.

For old steel bridges, the weight in pounds may be approximated by formula. $W=L(250+2.5L)$ Where L=span in ft.

Surface area per ton=200 sq. ft.

One man will paint 60 sq. ft. per hour for field costs. (Shop coat 120 sq. ft. per hour.)

Assume: Paint—$1.70 blue; $1.92 tinted per gallon. Labor—$0.45 per hour.

Painting New Steel Bridges

Paint $(\frac{1}{2}+\frac{1}{2}+\frac{1}{2})\times 1.77=$	$2.65
Labor, Shop Coat $1\times\frac{200}{120}\times 0.45=$	.75
Labor, Field Coats $2\times\frac{200}{60}\times 0.45=$	3.00
	$6.40
Profit 25 per cent	1.60
Total	$8.00 per ton
	$0.0040 per pound

Cost Data on Various Types of Structures

This information has been secured from actual records kept by inspectors on bridge construction and applies to structures designed and built under the supervision of the Division of Highways. The labor items are given in man-hours so that variations in the prices of labor may be readily figured.

Type of Structure	Box Culvert	Slab Bridge	Thru Girder Bridge	Deck Girder Bridge	Plain Concrete Abutments	Arch Open Spandrel	6 inch Concrete Floor
No. bridges considered	83	93	48	3	5	1	—
	Man Hours per Cubic Yard of Concrete						
Building Forms	4.24	4.41	4.71	7.04	2 69	14.86	3.07
Mixing & Placing Concrete	3 97	4.65	4.33	3 87	3.45	4 18	6.28
Bending & Placing Steel	0 68	0 75	1 51	1 24	—	5 20	0.31
Excavation	4.22	4.50	5.21	4 17	5.65	484	—
	Feet B M per Cubic Yard of Concrete						
Form Lumber	24.20	16.53	17.54	20.23	10.00	4775	30.70
	Pounds per Cubic Yard of Concrete						
Average Amount of Reinforcing Steel	100	Sup 190 Sub 70	Sup 230 Sub 85	Sup. 290 Sub 85	—		100

Cost per Cubic Yard for Form Lumber

On bridges or abutments over 28 ft. from crown to stream bed add 8 to 10 percent to the above figures. (Concrete floors excluded.)

Cost per MBM	Box Culverts	Slab Bridges	Thru Girder Bridges	Deck Girder Bridges	Arch Open Spandrel	P.C Abut's & Piers	6" Concrete Floor	6" Removable Con Floor	R.C Abut's	R.C Tieback Abut's
$30.00	.73	.50	53	61	1.43	.30	.92	1.15	.50	.53
35.00	.85	.58	61	.71	1.67	.35	1.07	1.34	.58	.61
40.00	97	66	70	81	1 91	.40	1 23	1.54	.66	.70
45.00	1.09	.74	79	91	2 15	45	1 38	1.73	74	.79
50.00	1.21	.83	.88	101	239	50	154	192	.83	.88
55.00	1.33	.91	.97	111	263	55	169	2.11	.91	.97
60.00	1.45	99	105	121	287	60	184	230	.99	105
65.00	157	107	1.14	132	310	65	200	2.49	1.07	114
70.00	169	116	123	142	334	70	215	269	116	1.23
75.00	181	124	132	1.52	3.58	75	230	288	1.24	1.32
80.00	194	132	1.40	162	382	80	2.46	307	132	140
Ft.B.M	24.2	16.53	17.54	20.23	47.75	10.00	30.70			

Cost per Cubic Yard for Mixing and Placing Concrete

Cost of Labor per Hr.	Box Culverts	Slab Bridges	Thru Girder Bridges	Deck Girder Bridges	Arch Open Spandrel	PC Abut's & Piers	6" Concrete Floor	6" Removable Con. Floor	RC Abut's	RC Tied-back Abut's
$0.25	.99	1.16	108	87	1.04	.86	157	157	116	108
0.30	119	140	130	1.16	1.25	103	188	188	140	130
0.35	139	163	152	1.35	146	121	220	220	163	152
0.40	159	186	173	1.55	167	138	251	251	186	173
0.45	1.79	209	195	1.74	188	155	283	283	209	195
0.50	198	2.32	217	1.94	209	172	3.14	3.14	232	2.17
0.55	218	256	238	213	230	1.90	345	345	2.56	2.38
0.60	238	279	260	232	2.51	207	3 77	3.77	2 79	2.60
0.65	258	302	282	252	2 72	224	4 08	4.08	302	282
0.70	278	326	303	271	293	242	440	440	3.26	303
0.75	298	349	325	290	313	259	4 71	4 71	3.49	3.25
0.80	318	372	346	310	334	276	502	5.02	3 72	346
0.85	337	395	368	3 29	3.55	293	5.34	5 34	3 95	368
Hrs	3.97	4.65	433	387	4 18	345	6.28			

Cost per Cubic Yards for Building Forms

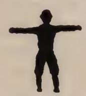
On bridges or abutments over 28 ft. from crown to stream bed add 8 to 10 percent to the above figures. (Concrete excluded.)

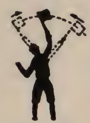
Cost of Labor per Hr	Box Culverts	Slab Bridges	Thru Girder Bridges	Deck Girder Bridges	Arch Open Spandrel	P.C. Abut's & Piers	6" Concrete Floor	6" Removable Con Floor	RC Abut's	R.C. Tied-back Abut's
$0.25	1.06	1 10	1.18	1.76	3 71	67	.77	96	1.10	1 18
0.30	127	1.32	1.41	2 11	446	81	92	115	1 32	141
0.35	148	154	165	246	5.20	94	1 07	134	154	165
0.40	1 70	176	188	282	5.94	108	123	154	176	188
0.45	1 91	1.98	212	317	669	121	138	1 73	198	212
0.50	212	2.20	235	352	743	134	153	192	220	2.35
0.55	233	2.43	259	387	8 17	148	169	211	2.43	259
0.60	254	265	283	4.22	892	161	184	230	265	283
0.65	276	2.87	306	4.58	966	175	200	249	287	306
0.70	297	309	330	4.93	1040	188	215	269	309	3.30
0.75	318	331	353	5.28	11.14	202	230	288	331	353
0.80	339	353	377	5.63	1189	215	246	307	353	377
0.85	360	375	400	5.98	1263	229	261	3.26	375	400
Hrs	4 24	4.41	4.71	704	14.06	269	307			

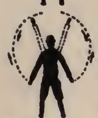
Signals for Use on Survey Work

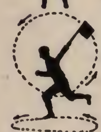
Instructions to Survey Parties Given in Standards of Divsion of Construction of Indiana State Highway Commission

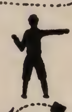
On survey work considerable communication must be done by means of signals. Such should be as simple and unmistakable in meaning as possible and known to all members of the party. The following are suggested for use, many of them being long established practice:

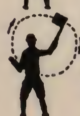

Extending both arms horizontally once, or waving them once slightly above or below horizontal: "ALL RIGHT". (Close-up signal)


Waving one or both arms back and forth over the head holding a red or white flag, etc., in the hand: "ALL RIGHT." (Distance signal).

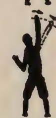

Both arms extended downward, diagonally, and raised, extended, to nearly meet over the head, then dropped to downward position again, repeat second time: "ALL RIGHT, COME AHEAD."

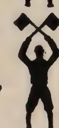

Running back an forth in a direction perpendicular to line, at same time waving, in big circle, arm holding flag of some kind: "ALL RIGHT, COME AHEAD" (Long distance signal).

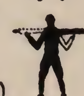

Extending or waving one arm out away from one: "MOVE OVER IN THAT DIRECTION." (Close-up signal).


Waving arm (holding flag in hand) to one side, in circle, so that flag moves away from one at top of circle toward desired direction of move: "MOVE OVER IN THAT DIRECTION." (Distance signal).

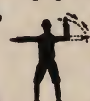

Extending arm vertically, holding position a moment, then dropping vertically, repeating until seen: "ROD UP"

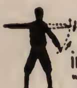

Extending arm vertically, holding position an instant, then making short wave toward one side "PLUMB ROD IN THAT DIRECTION."


Holding arms, or flags, crossed, motionless, over head: "CAN'T SEE YOU."

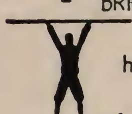

(Transitman) extending arms horizontally, one at a time, and drawing them back, alternating, repeatedly: "TAKE SECOND POINT FOR DOUBLE CENTER"

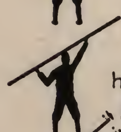

Extending arms horizontally, holding upper arms rigid, waving forearms up toward head and back down repeatedly: "COME THIS WAY AND BRING EQUIPMENT."

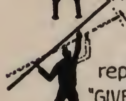

Extending arms horizontally, holding one rigid, waving forearm of other toward head and back down repeatedly: "BRING STAKES".


Extending arms horizontally, holding one rigid, waving other downward and back, repeatedly— waving right arm: "BRING WOOD HUB"— waving left arm: "BRING IRON PIN."

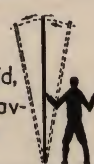

Standing sidewise, arms extended forward, wave them up and down, raising one while the other is being lowered, in a chopping motion: "BRING CUTTING TOOLS" (axes, cornknives, etc.).

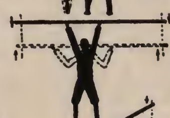

Holding flag rod horizontally overhead: "GIVE ME LINE FOR A HUB."

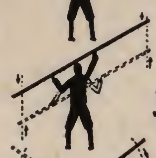

Holding flag rod on about 45° slant to horizontal, over head: "GIVE ME LINE FOR A TACK."

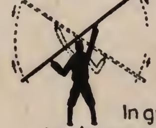

Holding flag rod on a slant over head, repeatedly raising and lowering upper end: "GIVE ME SECOND TACK POINT FOR DOUBLE CENTER."


Holding flag rod vertically, moving it up and down; or, holding flag rod vertically with bottom on point, moving one hand, or a flag, up and down before it: "SET ON THIS".


Holding flag rod vertically with end on ground, waving top too and fro across the line: "GIVE ME LINE"


Holding flag rod horizontally over head, moving it up and down rapidly "Double center line for hub".


Holding flag rod on a slant over head, repeatedly raising and lowering whole rod: "GIVE ME DOUBLE CENTER TACK POINTS"


Holding flag rod over head, raise and lower ends, rotating about center of rod held at a point: "REPEAT COMPLETE OPERATION."

In giving signals care should be taken to give them in the best manner to be seen; movement of arms should be greater and wider as distance increases; flags should be such as will show up against the background (as for instance white or bright red against green or dark background but darker colors, as a black hat, or something large and opaque, against a bright sky). If possible always stand out in the sunlight when signalling, also where possible stand on a high place where the sky will be the background. In getting line for a point with the rod let sunlight fall on rod if possible; using pencil or plumb cord sight hold contrasting background behind them, as a white page of a note book behind pencil, or block boot top or trouser leg back of white bob cord or yellow pencil. An army sergeant's whistle is sometimes useful to the instrument man for signalling.